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A CASE STUDY:
THE USE OF A COMPUTER ASSISTED INTERACTIVE VIDEODISC IN THE TEACHING OF THE CONCEPT OF LINEAR MOTION IN PHYSICS

by ©

VLADIMIR L. PASEK

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF EDUCATION

IN

INSTRUCTIONAL TECHNOLOGY

DEPARTMENT OF ADULT, CAREER AND TECHNOLOGY
EDUCATION

EDMONTON, ALBERTA
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Dear Mr. Fraser,

At present, I am completing a Masters Degree in Education at the University of Alberta. In my thesis, I prepared a pretest/posttest to evaluate my seven subjects who had followed a computer assisted interactive videodisc on linear motion.

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P. Wright

Peter W. Wright

J. F. Ilott

J. Fred Ilott

J. J. LaFollette

Jim LaFollette

SEPTEMBER 25, 1992

DEDICATION

To my wife, Denise, who understood my ambition and always encouraged me to continue in my endeavours. Her love for me and patience carried me through difficult times.

To my children, Martine, Tristan and Damien, who have waited patiently for me to complete my work.

To my parents, Vladimir and Elena, who always encouraged me to continue my education.

ABSTRACT

The object of this study was to determine whether the use of a computer assisted interactive videodisc (CAIV) package (a Level III type of interactivity driven by HyperCard) using "real life" experiments, can facilitate the students in achieving the following objectives:

1. Students upon observing linear motion will be able to use the mathematics of graphing in order to plot linear motion on a displacement versus time graph, a velocity versus time graph, and an acceleration versus time graph.
2. Students upon studying a graph of linear motion will be able to interpret and describe qualitatively and quantitatively the movement that has taken place in terms of displacement, velocity, and acceleration.

A group of seven Archbishop O'Leary High School students were selected from three Physics 10 classes according to the following criteria:

1. They volunteered for the study.
2. Returned their signed parent/guardian consent form.
3. Their grade nine science mark was between 55% and 65%.
4. They were about to take Physics 10 for the first time.
5. Their mark on the pretest was within 15% of the mean mark.

These seven selected students, covered a unit on graphical analysis of linear motion in physics by using the CAIV approach instead of attending

regular class. The average time spent on the CAIV tutorial was 3.7 hours. An additional average of 2 hours were spent with the author reviewing the homework and answering questions on the concepts and thus, the average time needed to complete the unit on graphical analysis of linear motion using the CAIV approach was 5.7 hours. In a regular classroom this section takes a total of approximately 12 hours (8 hours teaching the concepts and 4 hours reviewing homework) and so it seems that it takes on the average half the time to cover the same material by using the CAIV approach. The mean pretest score of the students in the study was 41% and the mean posttest score was 52%. Therefore the percent gain was 27%

According to this study, the benefits of the CAIV approach were:

1. Reduced learning time
2. Instructional consistency
3. Self-paced learning
4. Increased motivation
5. Use of "real life" situations in learning
6. Positive attitude towards learning

Therefore, this study has found that the CAIV approach is a viable method in the teaching of the concept of linear motion in physics.

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to Dr. P. Wright for being patient and always available in times of stress. He never lost faith in me.

Special thanks are extended to my committee members Dr. J. Fred Ilott and Dr. J. LaFollette.

I am grateful to Dr. L. Katz for taking the time to show me the facilities at the University of Calgary and discussing different types of instructional technologies.

Thanks are due to Dr. D. Zollman for informing me on the availibility of the videodisc entitled *Physics of Sports*.

I also want to thank Darryl Smith of Archbishop Austin O'Brian High School for piloting my pretest/posttest.

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CHAPTER I

INTRODUCTION

ORIENTATION

Throughout history man has had many sayings, such as "seeing is believing", "a picture says a thousand words" and "experience is the best teacher". In education, we try to address these statements when we plan our curricula. Many times it is difficult to see objects at first hand or it may be too dangerous to do an experiment (Looms, 1987; Stevens, Zech and Katkanant, 1987). Very often, it is too expensive. In order to educate our children, we place them in classrooms of about 30 students and try to teach them about the world.

The lecture method is the most common way of transmitting information to the student. At times, the teacher uses the chalkboard to reinforce a verbal explanation. There are occasions when the teacher will use some form of audio -visual material to enhance his or her presentation. Another method of learning which became popular in science was the discovery method, by which the student would learn a concept or law by performing experiments. Lately computers have been used to simulate experiments.

Due to the rapid development of technology, it is possible to combine much of our audio-visual material into one package. The videodisc is one type of package that can achieve this kind of integration. Teachers can now have at their fingertips a vast array of visual databases which can enhance a presentation. The contents of slides and films can be stored on a videodisc and information can be accessed within seconds. Each frame of the film can be frozen and analyzed facilitating the direct measurement of whatever action is taking place on the monitor. The clarity of the picture is excellent whether it is on the still function or the slow motion function (Greetfeld, 1987). One can freeze a frame and discuss or interpret what is happening. This feature is paramount in obtaining measurements off the screen in order to perform experiments. One method in accomplishing this feat is by placing a transparent acetate sheet on the frozen picture and then marking the position of the same person or object in different frames. This procedure helps the student in being able to transfer a filmed action which the student may have experienced in everyday life, such as running, onto a graph.

By combining a videodisc player with an external computer, this vast array of visual databases on a videodisc can be individually controlled by a computer program which drives the tutorial so as to produce what is called a level III type of interactivity. According to Schwier (1987) the "level III interactivity combines the power, patience, and versatility of a computer with the quality, realism, and aesthetic appeal of the videodisc." (p. 42). A computer assisted instruction (CAI) package can be developed such that the computer is the main source of instruction and the videodisc is used as a subordinate peripheral device. Using this kind of configuration and depending on the program, the student can have control of the pace and sequence of instruction.

PROBLEM STATEMENT

The author has observed throughout his eleven years of teaching Physics 10 in Alberta that students have difficulty in understanding graphs which depict linear motion in kinematics. This section of physics is very important because it is the first part in most physics curricula throughout North America. Many students cannot interpret the graphs depicting linear motion such as displacement versus time, velocity versus time, and acceleration versus time (McDermott, Rosenquist and van Zee, 1987). Students also have difficulty in connecting graphs to physical concepts and difficulty in connecting graphs to the real world (McDermott et al., 1987). By observing the results achieved by students on many exams, the author found that they cannot understand that the graphs describe a particular type of motion. Visualization and verbalization of the action represented by the graphs presents itself as a difficult task for many students. The teacher usually tries to explain the events by the use of the chalkboard. One divides the graphs into several sections and tries to explain what type of motion had occurred at that particular section on the graph. One way of describing a certain motion is to have the students imagine that they are travelling on a bike and relating the points on the graph to what they are doing. This method requires some imagination. Another method of explanation would be the use of a film, depicting a certain motion and then observing the graph.

The *Physics of Sports* videodisc shows the action of several athletic events in which a certain type of motion occurred. The student, by freezing the frame, can make direct measurements on the monitor screen. The student can also have immediate access to any frame s/he wants thereby the exact time elapsed can be obtained.

The first problem is that students feel that physics is foreign to their everyday life experiences. In order for average students to achieve an understanding in physics, it is very important for them to be able to relate physics to their everyday experiences.

The second problem is that high school students in the introductory physics course have difficulty in comprehending the graphs of simple linear motion in the study of kinematics.

OBJECTIVES

The main objective in this study is to determine if, upon observing linear motion, students will be able to describe what has taken place by the use of the terms: a) displacement, b) velocity, and c) acceleration. This main objective can be divided into the following subordinate objectives: 1) Students upon observing linear motion will be able to use the mathematics of graphing in order to plot linear motion on a distance versus time graph, a velocity versus time graph, and an acceleration versus time graph. 2) Upon studying a graph of linear motion, students will be able to interpret and describe qualitatively and quantitatively the movement that has taken place in terms of displacement, velocity, and acceleration.

In order to achieve the above objectives, the students will use a computer assisted interactive videodisc (CAIV) package which was developed by the author.

DEFINITION OF TERMS

It is important to define some of the terms used in this thesis.

Concept. Ary, Jacobs, and Razavich (1985) describes the word concept as " an abstraction from observed events; it is a word that represents the similarities or common aspects of objects or events that are otherwise quite different from one another." (p. 27). Also, Landau (1975) states that a concept is "a mental image; especially, a generalized idea formed by combining the elements of a class into the notion of one object." (p. 279).

Computer assisted interactive videodisc (CAIV). A videodisc under the control of a computer program. The student follows the instructions of the computer program, and depending on the student's response, information is presented from the videodisc or the computer.

Kinematics. Miller, Dillon, and Smith (1980) describe kinematics as "the description of motion, without regard to causes." (p. 48).

Level of interactivity. This is defined by Schwier (1987) as "The potential for interaction prescribed by the capabilities of videodisc hardware and external intervention. Conventionally, Levels I, II, and III are labels used." (p. 173).

Level III. Schwier defines this as "A videodisc presentation controlled externally, often by a computer. The computer controls the presentation, and the videodisc player acts as a peripheral device." (p. 173).

Linear motion. Motion along a straight line.

Physics. According to Genzer and Younger (1981) "Physics, then, is a way of thinking, a fundamental science, which is basically concerned with certain types of questions and problems that relate to matter and energy interactions." (p. 3).

Videodisc. Video and audio information are stored on this object which resembles an audio Long Playing (LP) record but appears to be silvery metallic. A laser scans the videodisc and reads the information from it.

CHAPTER II

REVIEW OF THE LITERATURE

INTRODUCTION

The following review of the literature attests to the relevance and effectiveness of a CAIV approach to the teaching of a concept in physics. The literature focusses on studies which justify the use of CAIV.

WHY USE REAL LIFE SITUATIONS?

Some persons might suggest that devices such as air tracks are the best way to demonstrate linear motion. While these devices can be effective, students identify more strongly with their experiences from everyday life, such as, riding a bicycle, running, and walking. According to Zollman, Noble, and Curtin (1987) "Physics teachers have long used visual media to show how the principles of physics can be applied to everyday events. These examples seem to motivate students and to improve their understanding of the concepts being taught." (p. 249).

Several years ago, Hafner (1959) produced a film for the Physical Science Study Committee with the help of the National Science Foundation. In this film, he showed a real life situation, such as a car travelling on the highway while at the same time, each of the following three graphs was drawn by three different electronic plotters: (1) a distance versus time graph; (2) a velocity versus time graph; and (3) an acceleration versus time graph. Hafner was driving the car and describing what he was doing while, simultaneously the graphs were being plotted. In the film, Hafner stated that: "Understanding kinematics is essential in order to be able to comprehend many things that follow later on in physics." Nowadays, every student has had the experience of riding in a car and therefore s/he can relate to the film.

WHY USE REAL-TIME GRAPHING?

Brasell (1987) found that if there was a delay of only 20 to 30 seconds between observing the motion and seeing the graph of that motion, the student would not learn as well as compared to observing the motion and seeing the graph simultaneously. Retention of the learning lasted longer with the latter method. The following paragraphs reflect Brasell's reasoning:

> There are at least three possible reasons, which are neither distinct nor incompatible: (a) the task exceeded the students' memory capacity, (b) the task required more effort than students were prepared to expend (motivation), or (c) students did not know how to retain the information about the event until the graph was displayed. (p. 393)

Also:

> Assuming that the initial entry and processing of information in the brain takes place in short-term memory, real-time graphing may allow rapid cognitive linking within short-term memory (e.g., of a physical event and a point on a graph) and thus increase the likelihood of the linked information being transferred to long-term memory as a single unit. (p. 386)

According to Brasell (1987), it seemed that the real-time graphing "made the graphs appear more responsive, more manipulable, and more concrete." (p. 394). In conclusion Brasell states that: "Real-time graphing of data appears to be a key feature for both cognition and motivation. It allows students to process information about a physical event and its graph simultaneously rather than serially." (p. 394).

In the late sixties, film loops were popular. Meiners (1967) produced a film loop entitled *One Dimensional Motion.* In the notes given with the film-loop, he states that:

> This Film-Loop shows the displacement, velocity, and acceleration of a small cart as it is pulled back and forth along a ten foot section of track. At the beginning of the film, you can see the cart, the drive system, and some of the associated equipment for measuring and displaying these parameters in real time... After you have been introduced to the apparatus, you will see the cart in three successive scenes as it travels down the track and back again. As you watch the cart in the lower half of the picture, you will see the X-Y recorder in the upper half plotting first displacement, then velocity, and finally acceleration. (notes given with the film-loop)

In order for students to retain concepts and to maintain their motivation, it is very important that the CAIV package shows the linear motion of an object while simultaneously graphing the motion.

WHY USE A VIDEODISC?

The videodisc stores slides and films which can be accessed within seconds. Each frame of the videodisc can be frozen and analyzed which facilitates the direct measurement of whatever action is taking place on the monitor (Zollman et al., 1987). Looms (1987) found that in one of the interactive videodiscs the "individual sequences and frames were accessed manually using a remote control device and the groups measured movements directly from the screen to support their hypotheses" (p. 176). Greetfeld (1987) found that the clarity of the picture is excellent whether it is on the still function or the slow motion function. When the teacher needs to show a demonstration, s/he can immediately access the desired topic (Looms, 1987), freeze the frame and discuss or interpret what is happening. When the videodisc is used with an entire class, Van de Wiele (1987) found that:

> The remote control is sufficient and is perfect for this sort of situation. Its mastery gives rhythm to the lesson. The ability to stop a sequence, to see it again at the normal speed or in slow motion, etc., enables the students to follow the action, to describe it or comment on it at different times, . . . (p. 190)

Due to the fact that the picture can be frozen and remain quite clear, the student can take direct measurements off the screen by using an acetate sheet (Zollman et al., 1987). In the background of the images of the interactive videodisc *Physics of Sports* there are reference markers in meters so that the student can convert the distances from screen to real life. By using this method the students will be able to perform experiments which would otherwise be difficult to do (Zollman et al., 1987).

Simultaneously depicting linear motion with the corresponding graph could be accomplished using other forms of media such as film, film-loop, or video-tape but several factors have to be considered. One such factor is durability. The videodisc is the most durable when compared to the above mentioned media. As well, videodiscs provide for the rapid random access to any particular segment. The videodisc is best used when pictures of the real phenomena are essential in the presentation of a concept (Bork, 1982). Other advantages of using the videodisc, as observed by Romiszowski (1988), are:

> - a very high storage capacity for its size (a single laser videodisc about the size of a grammophone record, may store over 100,000 still images or pages of text, or about 500 hours of audio recording, or about two hours of full audiovisual, twin soundtrack, stereo video programming);
> - flexibility of storage (the same disc may be used to store any combination of stills, moving images, text, or indeed any information that can be digitized - computer programs for example); (p. 341-342).

WHAT ABOUT INTERACTIVITY?

According to Smith (1987):

> Interactive video is the use of a video delivery system designed in such a way that will respond to choices made by the individual user. These choices may be spontaneous on the part of the user or they may be prompted by the system. (p. 2)

Interactivity is important because the student becomes an active participant in the instruction and learning process. Priestman (cited in Smith, 1987) found that it is better to use a medium in which there is active participation by students than passive participation. Golberg (cited in Smith) discovered that using an interactive videodisc was more effective in training than the text, slides, or videotape.

The videodisc, especially in conjunction with the computer, can be a powerful tool in education as Heyer (1984) stated:

> For the first time in history, our visual information environment can be put directly under control of our individual minds and wills. The combination of computers and videodiscs can be used to increase personal processing capabilities, perhaps based on whole new languages using spatial graphic symbology rather than text. (p. 102)

Wenger (1987) stated that "It is accepted that, to achieve the greatest benefit from interactivity with students, the use of the microcomputer coupled with a videodisc gives results which up to now are unrivalled in the field of teaching" (p. 183).

In another study done by Branch, Ledford, Robertson and Robinson (1987), It was found that, at times, the use of interactive videodiscs can be effective as an alternative to traditional techniques. Overall according to a review by Bosco (1986) the interactive videodisc aids in student achievement, user attitude, performance, and learning time but the most affected, are user attitude and decreased learning time. Hofmeister, Engelmann and Carnine (1985) found that "Of the technological alternatives presently available, interactive videodisc instruction appears to be the one best suited for modeling effective teaching presentations and increasing student achievement" (p. 37).

Das, Agrawal, and Pushkarna (1988) state that:

> To summarize, the available evidence suggests that videodisc is a highly effective instructional medium across all types of educational and training applications. Students who learn via interactive video achieve better test results with less time required. Videodisc is well accepted by students, instructors, employees, and managers. In the hands of talented and experienced instructional developers, videodisc has been demonstrated to be one of the most powerful instructional technologies currently available. (p. 340)

To conclude, it seems apparent from the above related literature that one possible method of presenting the concept of linear motion in physics is by the use of CAIV.

CHAPTER III

THE DEVELOPMENTAL STAGE

DEVELOPMENTAL ENVIRONMENT

Having decided to use a Level III CAIV approach to the study, a search was undertaken to determine what, if any, available resources addressed the problem. At the time the study was initiated, no such resources were available and thus, the decision was made to pursue in-house development featuring the use of an authoring tool, a computer and a videodisc.

The first step was to determine whether to use an authoring system or an authoring language. Schwier (1987) defines an authoring system as "A computer program which is designed for computer assisted instruction development. Procedures are predefined, and require little or no programming knowledge on the part of the user." (p. 171), and an authoring language as "A computer language which is specifically designed for developing computer-assisted instruction. In order to be effective, the user requires some knowledge of computer programming." (p. 171). The decision was made to use an authoring language rather than an authoring system. The choice was HyperCard (which incorporates a language called HyperTalk). According to Abes (1992), HyperCard is widely used as an authoring tool.

The rationale for using HyperCard was that it is easily programmable for the purpose of computer assisted instruction, readily available, widely used, and affordable. Since September of 1987, the program HyperCard has been included with the purchase of a Macintosh computer thereby suggesting that Apple Computer Inc. will maintain the program for a long time. According to Milone (1988) the Macintosh computer will become an attractive tool in education because it uses the HyperCard program. Friedler and Shabo (1989) stated many strengths of the HyperCard software package:

> A. For software developers.
> 1) Easy and convenient operation of the program at the development level. 2) Flexibility in terms of creating the final product, which may include databases, learning activities, and evaluation of student responses. All of these can be developed using a single development system. 3) Existence of a friendly interface. 4) Easy integration of graphics and animation as part of the database. 5) Low cost. HyperCard is a public domain program which has been supplied, free of charge, to purchasers of Macintosh computers as of September, 1987.
>
> B. For the end-users.
> 1) Existence of a friendly interface. 2) Convenient and easy accessibility to the databases by using HyperText or by using menus and icons. 3) Presentation of data in different forms: graphics, illustrations, and text. HyperCard enables users to view textual information only, or to view a combination of diagrams, drawings, and appropriate text. 4) The existing database is easily expandable. 5) Low cost. The users do not have to pay for the privilege of running an application written as a result of using the HyperCard program. The added cost of run-versions is nonexistent since the product itself is in the public domain. (p. 48)

One of HyperCard's major strengths is that it facilitates the management of information from mass storage devices such as CD-ROM's, and videodiscs; it is therefore well suited to a level III type of interactivity.

The computer chosen both for development and implementation was the Macintosh SE with 2MB RAM, and an internal 40MB hard drive. One of the important reasons for choosing the Macintosh was its increasing popularity in the schools. As stated by McCarroll (1991) "the Macintosh caught on well in the home and school markets, where Apple's machines now outsell IBM's by a two -to-one margin." (p. 67).

The decision was made to incorporate Zollman's *Physics of Sports* videodisc in the tutorial. This videodisc contains various filmed athletic events featuring linear motion from which students can obtain all sorts of data in order to perform experiments. When the athletic events were filmed, a reference marker was always present in the scenes so that a conversion factor could be calculated in order to determine the real distances. The videodisc is accompanied by a teacher's handbook and a student's handbook which explain the various experiments that can be performed. Only the scenes that dealt with linear motion were used for developing the CAIV package for this study.

One other type of software was needed to link the computer and the videodisc player - a software that makes videodiscs interactive with HyperCard.

The Voyager VideoStack 2.0™ program was used for this purpose because it simplifies the aspect of making interactive video lessons. The designer has to answer questions on the screen and the program automatically produces a button which can be inserted in the HyperCard program with ease. This program can easily work with just about any videodisc player. Nothing had to be altered when switching from the LV-D4200 to the LV-D2200 which helped during the developmental stage.

Two types of videodisc players are currently available. One is called the industrial type which has the RS-232 port that easily connects via a cable to a computer. The other is called the consumer type which needs a special piece of hardware, called the *BOX* (provided by the Voyager Company) which is used to interface the computer and the videodisc player. The problem is that the consumer types do not provide as much control as the industrial types. For example, the industrial type player can tell the computer which frame is being used if asked by the computer but the consumer type can't perform this task. The Pioneer LV-D2200 (an industrial type) was utilized in the developmental stage and during the implementation stage.

INSTRUCTIONAL DESIGN

The instructional design for the CAIV was based substantially on the Dick and Carey model which is shown in Figure 1. Nine of the ten steps outlined in the Dick and Carey model were employed in this study.

The first step was to identify an instructional goal. The instructional goal, which is the main objective of this study, states that when the students observe linear motion they will be able to describe what has taken place by the use of the terms: a) displacement, b) velocity, and c) acceleration. The reasons for this goal are stated in chapter I of this study, in the problem statement section.

The second step was to conduct an instructional analysis. In order to achieve the instructional goal, it was determined that the domain of learning would be in the category of intellectual skills. The reason for the above category is that the learner has to manipulate symbolic information in some way, for example graphs, in order to arrive at a solution. All four types (discriminations, concepts, rules, and problem solving) of intellectual skills were used.

The following is an example of the steps used to achieve part of the first subobjective which states that students upon observing linear motion will be able to use the mathematics of graphing in order to plot the linear motion on a distance versus time graph: 1) Construct a data table with the following three columns: position number, time, and distance, 2) Determine the distance

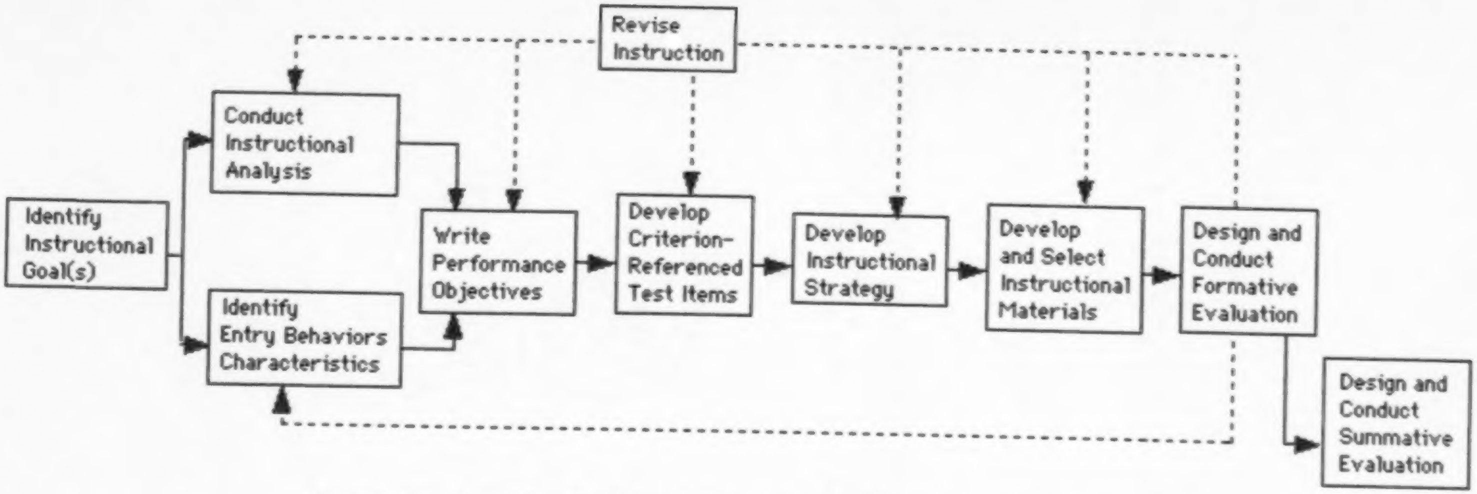
Identify Instructional Goal(s)
Conduct Instructional Analysis
Identify Entry Behaviors Characteristics
Write Performance Objectives
Revise Instruction
Develop Criterion-Referenced Test Items
Develop Instructional Strategy
Develop and Select Instructional Materials
Design and Conduct Formative Evaluation
Design and Conduct Summative Evaluation

FIGURE 1 The 'Dick and Carey' model for instructional design

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between the reference position (starting position) and a selected position, 3) Record the distances and the corresponding times for each of the selected points in the data table, 4) Draw a distance versus time graph, 5) Plot the points on the distance versus time graph, 6) Draw the best fit line through the points.

In order for a student to perform those skills in the above steps, s/he will have to know several subskills. These subskills are included with the objectives in Appendix A.

As to the step which deals with the entry behaviors and characteristics, it was required that students who participated in the research were first time attendees of the grade 10 physics course, entitled Physics 10. The students would also have to know how to use two dimentional graphs and be able to measure distances with a ruler.

The writing of the performance objectives was the subsequent step in the 'Dick and Carey' model. Examples of performance objectives to the above step can be seen in Appendix A, in conjuction with the skills and subskills.

The next step was the development of criterion-referenced test items. After having listed the objectives for the various sections of the tutorial, the questions that would be used in the formative evaluation of each section and in the summative evaluation were assembled. The regular homework which is given every year was used as the formative evaluation. Examples of homework sheets that were given to the students have been placed in Appendix B.

A single pretest/posttest was constructed to be administered to the students. The reasons for the pretest were to; a) determine the knowledge of the student prior to doing the tutorial and b) serve as a criterion for selecting the students for this study. The pretest/posttest was constructed from existing test item banks such as teachers' banks, The Australian Council for Educational Research Physics Unit Tests, Tests on Duplicating Masters for PSSC Physics fifth edition, and Science Teaching Tests for Concepts in Physics Third Edition. Questions that evaluated the performance objectives of the tutorial were selected accordingly. The pretest/posttest was organized in such a manner that the questions at first tested the knowledge then the comprehension of the various graphs and their construction.

The pretest/posttest was piloted at Archbishop Austin O'Brian High School (Edmonton Catholic School District) to determine whether there were any problems and whether any revisions would be appropriate. The exam was administered when the students were reviewing the material for their final exam which was due two weeks from that date. Table 1 illustrates the results obtained. Each test item was looked at to determine if it was understood and to assure that no mistakes were apparent.

TABLE 1
Results of piloted pretest/posttest
N= 23

Mean	64%
Standard deviation	15%
KR-20 reliability	0.8

The next step in Dick and Carey's model is developing an instructional strategy. Dick and Carey (1985) mention five major components to this step: 1) Preinstructional activities, 2) information presentation, 3) student participation, 4) testing, 5) follow through. In order to motivate the student at the start, a clip of film from the videodisc dealing with the content of what would be covered was placed in the introduction part. The tutorial was divided into six parts, each with its own objectives and homework. Student participation was achieved by the interaction of the student with the computer. If the student answered incorrectly, s/he was reminded by the computer and the student would have to answer correctly before continuing. The student had the option of reviewing the material. Testing and follow-through activities were accomplished by the student doing the homework which was corrected by the author. Explanations were given by the author when the students encountered difficulties with their homework.

The student would work with two screens (a computer screen and a TV monitor). The computer screen provided the instructions for the tutorial while the TV monitor delivered the images (used in the experiments) from the videodisc.

The development and selection of instructional materials came next in the model. This tutorial package comes under the heading of individualized instruction. A computer assisted interactive videodisc was the medium used to accomplish the instructional goal. As mentioned earlier, this CAIV package was developed as a Level III type of interactivity. There were six units developed. Each unit had its objectives. Many of the strong points of HyperCard were used, such as, the facility of doing animations, the use of fields and buttons, the ease of navigating through the tutorial, the ease of integrating text and graphic design and the use of graphics.

A jump-linear stack structure was used in designing the basic structure of the tutorial. In other words, most of the time the student would move linearly throughout the tutorial but at the end of each unit s/he could go back to the main menu or continue. Also, when a term was used later in the lessons, the student had the option of pressing the button of the term and immediately s/he was brought to the card which explained the term and gave examples. After the student reviewed the definition of the term, s/he clicked on the return button which sent them back to their original spot and thus they were able to continue the lesson. This process is similar to HyperText. During the interactive parts, the answers had to be correct, otherwise the student couldn't proceed to the next screen. S/he had the option of returning to the previous lesson in order to review the material.

The important thing was to make sure that the tutorial would not be an electronic book (screen after screen with just written material). In other words, as many of the features mentioned earlier with HyperCard were used. For example when a student read a definition, s/he was presented with an animation of the action which was stated in the definition. Sound could have been used but there wasn't enough time to incorporate it into the program. Since a videodisc player was used, the program at times displayed on the TV monitor a certain part of a video and the student controlled the videodisc player via the buttons on the computer screen. This was convenient because, when the student performed the experiments, s/he had control of each individual frame.

One very important feature of the tutorial was showing the graph being drawn simultaneously as an object such as a car was displaying linear motion. This was accomplished by the use of animation. This action could be repeated as often as necessary for the student to learn.

On some other displays, after a button was pressed the steps of the calculations were shown at a certain pace while the action of the calculation was being shown graphically.

After two months of becoming familiar with HyperCard, the programming part of the CAIV took three months to accomplish.

The step in the model that dealt with the revision of the instruction was not fully adhered to. As the various steps were being developed, revisions were performed. Even though, the final version was not revised due to lack of time, the tutorial functioned well.

CHAPTER IV

RESEARCH METHODOLOGY

INTRODUCTION

The purpose of this study was to determine whether the use of a CAIV could fulfill the main objective which was to determine if, upon observing linear motion, students will be able to describe what has taken place by the use of the terms: a) displacement, b) velocity, and c) acceleration. This chapter will describe the population and sample, the study design, the instrumentation, the significance of study, and an account of the procedure used.

POPULATION AND SAMPLE

A group of seven Archbishop O'Leary High School students were selected from three Physics 10 classes according to the following criteria:

1. They volunteered for the study.
2. Returned their signed parent/guardian consent form (Appendix C).
3. Their grade nine science mark was between 55% and 65%.
4. They were about to take Physics 10 for the first time.
5. Their mark on the pretest was within 15% of the mean mark.

Table 2 demonstrates how the selection process narrowed the sample, from a total of 84 students down to 7 students.

TABLE 2
Selection of Students for Study

Criteria	Class 1 (N=32)	Class 2 (N=24)	Class 3 (N=28)	Total (N=84)
	Number of Students meeting selection criteria (cumulatively)			
Volunteers	4	6	16	26
Signed consent forms	4	3	8	15
Grade nine Science mark between 55% and 65%	2	3	5	10
1st time registered in Physics 10	2	2	5	9
Pretest mark within ±15% of mean mark	1	2	4	7

These seven students were selected from the same school whose population was approximately 1500. The sample consisted of 5 males and 2 females.

STUDY DESIGN

This case study was conducted at the precise time when the graphing of the various motions were introduced in the regular Physics 10 course as prescribed in the Alberta Physics Curriculum. Before the selected students started the CAIV package, a pretest on the graphical analysis of linear motions was administered in three Physics 10 classes in order to implement one of the criteria for the selection process.

The sample students were instructed in the workings of the CAIV package before the start of the study. In other words, they were taught how to navigate through the package but were not exposed to the content of the *Physics of Sports* videodisc. The maximum number of hours permitted with the package was equivalent to the time spent in the classroom on the same topic. The students did not attend their regular Physics 10 classes but followed an assigned schedule. Worksheets with problems dealing with what was covered in the tutorial were given as homework and corrected upon their return with feedback.

After the sample students completed the package, they wrote a posttest in order to determine if the objectives of the study had been achieved. At the end, a questionnaire was also administered to determine their attitudes towards this CAIV package and this method of learning.

INSTRUMENTATION

The following instruments were used in this study:

1. An identical pretest and posttest.
2. A CAIV tutorial using a Level III type of interactivity.
3. Worksheets with questions dealing with the topics covered in the tutorial.
4. A questionnaire dealing with the students' attitudes and feedback on the instructional design of the CAIV.

The pretest contained 36 multiple choice questions which covered the objectives of the tutorial. Appendix D has the identical pretest and posttest.

Appendix E contains the questionnaire which was administered to the students at the termination of the posttest.

Appendix F shows photographs of the physical layout of the equipment. Appendix G contains a printout of the cards in the tutorial stack entitled *Motion*. The stack was printed in the order that the cards are placed in the stack. The hidden fields and hidden buttons cannot be seen, because the visible buttons on the screen have to be activated in order for them to display hidden elements.

PROCEDURE

This study was conducted over a period of 35 days, from the time the seven students began their tutorial to the time the posttest was administered. Table 3 depicts the weekly time alottment given each student to work on the tutorial. In Table 3, numbers were assigned to students instead of their names. The students were given enough time to complete the tutorial.

TABLE 3
Typical (weekly) study schedule for students

	Day of the week				
Time	Mon	Tue	Wed	Thu	Fri
7:30 - 8:00		4	4		4
11:35 - 12:00	7			7	
12:00 - 12:25	7	3	3		3
12:30 - 13:00		2			2
13:05 - 13:35		1			1
13:40 - 14:10			2	5	
14:15 - 14:45			1		
14:50 - 15:20	5	6	5		6
15:20 - 15:50					6

The same physics classroom was used for the duration of the study. The equipment was placed on a cart with wheels (see Appendix F) so that everything could be moved rapidly and easily into the empty classroom during the scheduled times. The Macintosh SE with the keyboard and the TV were placed on top of the cart whereas the videodisc player was underneath, on the second shelf, out of the way.

Before the student arrived for the tutorial, the equipment was in place and ready to start. At the scheduled time, the student was handed the necessary materials (a 30 cm plastic ruler, a 27 cm by 20 cm clear transparent acetate sheet, masking tape, and a marking pen). If the student had completed a previous session somewhere within a unit, s/he was aided in locating the last location, otherwise the student used the main menu to arrive at the desired location.

All the work, except the homework and the pretest and posttest, was accomplished on the computer. At times the computer screen had observation tables in which the student entered the results. When it was necessary to plot a graph, the student placed a dot of the coordinates on the screen with the use of the mouse. The correct graph of the action was drawn after the coordinates were plotted.

At the end of a section, the student was given a sheet with the questions and s/he did them as homework. During the following scheduled meeting, the homework was checked and whatever errors that were committed by the student were explained.

Throughout the scheduled time, the student was observed. Approximately two times, the student was given an explanation when s/he had difficulty in understanding the wording of the tutorial or could not progress.

Occasionally, students were filmed during some segments of the tutorial (especially, the part when they were taking data from the TV screen for the experiment). In Appendix F are photographs of students performing the experiment.

The assigned worksheets were corrected while the student was working on the tutorial and returned with explanations at the end of the prescribed time or in some cases before the commencement of the following time slot.

At the end of the session, the student's location (card ID) in the tutorial was noted and the respective worksheet with instructions was handed out.

CHAPTER V

RESULTS

INTRODUCTION

The object of this study was to determine whether, the use of a CAIV package having a Level III type of interactivity which utilizes "real life" experiments, can facilitate the students in achieving the following objectives:

1. Students upon observing linear motion will be able to use the mathematics of graphing in order to plot linear motion on a displacement versus time graph, a velocity versus time graph, and an acceleration versus time graph.
2. Students upon studying a graph of linear motion will be able to interpret and describe qualitatively and quantitatively the movement that has taken place in terms of displacement, velocity, and acceleration.

This chapter will present the following results:

1. The time utilized in following the tutorial.
2. A comparison of the results of the pretest and posttest by the use of the mean, standard deviation, and a correlation coefficient.
3. The means and standard deviations of instructional design perceptions of the students in the study.

4. The means and standard deviations of attitude ratings of the students in the study.
5. The advantages, disadvantages, and improvements needing to be addressed as discussed by the students in the questionnaire.

TIME SPENT ON TUTORIAL

Table 4, shows the time spent for every scheduled block by each student during the duration of the study. Weekends, and holidays were left out. March 8 was a professional development day for teachers but one student wanted to work on the tutorial. During the study, student 4 broke his ankle and therefore missed a week of school which accounts for the empty space for the week of February 25. Student 5 developed pneumonia and was absent from March 7 to March 18.

The reasons for not following the scheduled times were:

1. Illness
2. Extracurricular activities
3. Tardiness
4. Forgetfulness
5. Holidays
6. Teacher inservice days
7. Stopping and starting at a convenient place in the tutorial.

TABLE 4
A detailed account of students' times spent on the CAIV tutorial

Student Number	Time spent on the tutorial (min)																			
	February									March										Total
	13	14	15	19	20	25	26	27	28	1	4	5	6	7	8	11	12	13	14	
1	30			30	36		40	56				28	29				25			274
2	22		27				18			65		34	14					25		205
3	24		29	25	14					15		23	22				20			172
4	30		30	30	30						20	35	30	25						230
5	30	34			55	30			35				30							214
6			39	65			47					55			25					231
7		35				34			32		40			40		24			20	225

STUDENT PERFORMANCE OUTCOMES

In Table 5, the selected students' results are listed. The column labelled, deviation from pretest mean, was calculated by substracting 42% (the pretest mean of the original 84 students) from the selected students' pretest scores.

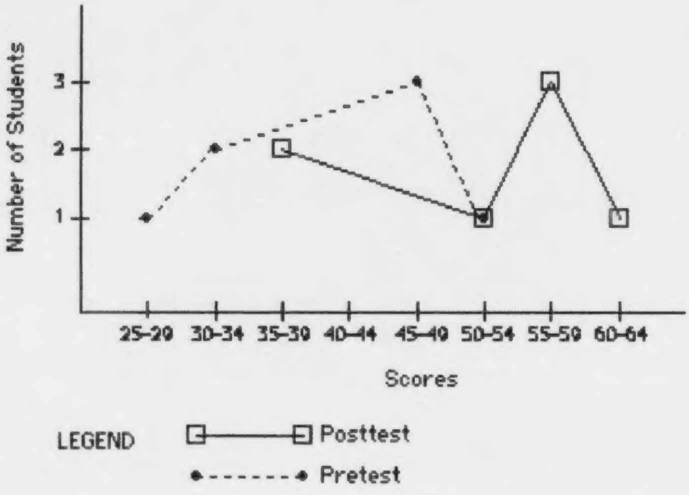
TABLE 5
Students' Results

Student Number	Grade 9 Science Mark (%)	Pretest Score (%)	Deviation from Pretest Mean (N=84) (%)	Posttest Score (%)	Percent Gain (%)	Time Spent on CAIV (h)
1	63	47	+5	61	30	4.6
2	63	47	+5	56	19	3.4
3	65	31	-11	39	26	2.9
4	65	47	+5	53	13	3.8
5	65	53	+11	58	9	3.6
6	55	33	-9	56	70	3.9
7	55	28	-14	39	39	3.8
Mean		41	-1	52	27	3.7
Standard Deviation		9.9		9.0		0.52

From the above table, the standard deviation between the pretest and posttest declined which is a positive factor in unifying the students' knowledge base of graphical analysis of linear motion in physics. Table 5 shows that the more time spent on the tutorial the higher the percentage increase between the posttest and the pretest.

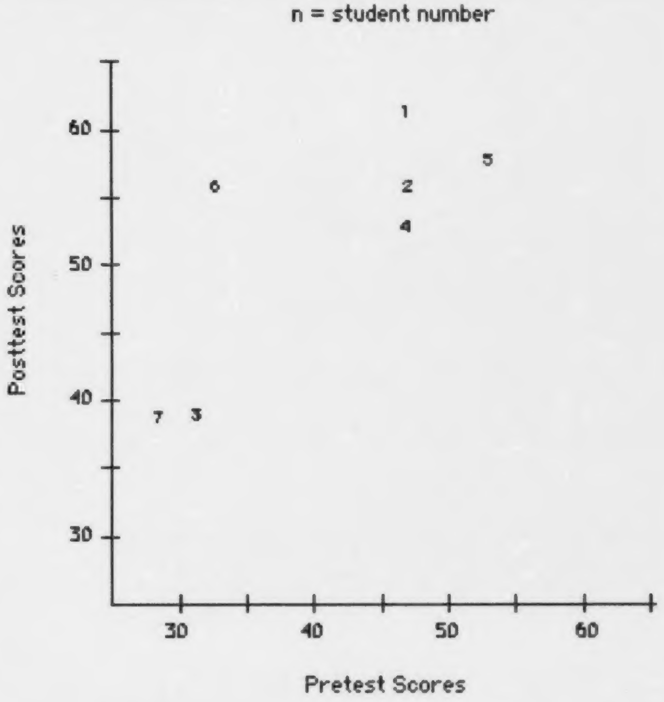
Another manner of visualizing the results is by the following frequency polygon graph shown in Figure 2.

FIGURE 2
Frequency polygon graph of pretest and posttest scores



In Figure 3, the scattergram shows that there is a positive relationship between the results obtained on the posttest exam and the pretest exam. The correlation coefficient (the product moment coefficient of correlation) was found to be 0.77 which is a high correlation. The students who obtained relatively high scores on the pretest, also obtained relatively high scores on the posttest after having done the CAIV.

FIGURE 3
A scattergram of the students' posttest results versus pretest scores



GENERAL STUDENT PERCEPTIONS OF THE CAIV TUTORIAL

After the posttest was written, a questionnaire (Appendix E) was administered to the seven students. This questionnaire focused on the instructional design and attitudes towards the use of CAIV in the teaching of the graphical analysis of linear motion in physics.

General student perceptions on the CAIV tutorial from an instructional design perspective are shown in Table 6.

The students agreed strongly (a mean of greater than 4.5) that this CAIV provided an easy way to enter their results on the computer's screen and that it allowed them to control the pace of learning. The mean for the instructional design was 4.2 with a standard deviation of 0.6 which shows that the students were consistent in their response as a group. All students involved in the study agreed that the CAIV maintained their interest (standard of deviation was zero).

STUDENT ATTITUDE TOWARDS THE USE OF CAIV

In Table 7, the results dealing with the students' attitudes towards this CAIV are listed. The students strongly agreed that they enjoyed learning by the use of this method. The other item that was rated high (4.3) was the part that stated that they were better able to relate to the graphs which they constructed because the data (results) were gathered from "real life" situations (i.e. videotaped atheletes in motion). The mean for the section on attitudes was 4.2 with a mean standard deviation of 0.7 which again shows that the students were consistent in their response as a group.

TABLE 6
Student perceptions of the use of the CAIV tutorial
N = 7

Questionnaire Items	Means*	SD
The tutorial on the graphical analysis of linear motion that I just completed		
Held my attention	4.3	0.5
Maintained my interest	4.0	0.0
Provided an easy way to enter my results on the computer's screen	4.7	0.5
Provided clear directions	4.1	0.7
Provided meaningful feedback	3.6	0.8
Allowed me to control the pace of learning	4.6	0.5
Provided meaningful animation	4.4	0.5
The order that the material was presented was well done	4.3	0.8
The diagrams were clearly drawn	4.3	0.8
The diagrams were clearly labelled	4.1	0.7
The homework related well to the tutorial	3.9	0.7
Instructional Design Mean	4.2	0.6

* Scale: 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree

TABLE 7
Student attitude towards the use of CAIV
N = 7

Questionnaire Items	Means[*]	SD
I enjoyed learning by the use of this method	4.7	0.5
I prefer learning science by this method	4.0	1.0
I enjoyed doing the labs in this manner	4.1	0.9
I believe this is an effective way of learning science	4.1	0.9
I was better able to relate to the graphs which I constructed because the data (results) was gathered from "real life" situations (i.e videotaped atheletes in motion)	4.3	0.5
I enjoyed using the buttons to activate different actions	4.0	0.6
Attitude Mean	4.2	0.7

[*] Scale: 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree

STUDENT PERCEPTION OF THE ADVANTAGE/DISADVANTAGE OF CAIV

At the end of the questionnaire, a section was provided for comments on the advantages and disadvantages of the CAIV approach. Two additional questions were asked. One of these questions asked the students how the CAIV tutorial could be improved while the other asked whether they worked harder, the same or less than in a regular course.

The following is a list of statements provided by the students on the advantages of the CAIV approach:

1. It took less time to learn the material.
2. I was able to work at my own pace (not rushed).
3. I received more personal attention from the teacher.
4. It allowed for revision.
5. It allowed graphing of real life situations.

The following is a list of statements provided by the students on the disadvantages of the CAIV approach:

1. There was no interaction with friends.
2. The teacher was not always around.
3. It allowed for slacking off.

The following is a list of statements provided by the students on the ways of improving this tutorial:

1. It should have more examples in certain parts.
2. It should have more questions and examples.
3. It should incorporate sound.
4. It should have some physical labs accompanying the program.

Five students said that they worked harder than in a regular course and two students said that they worked the same amount.

CHAPTER VI

SUMMARY OF RESULTS, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS FOR FURTHER STUDY

INTRODUCTION

The object of this study was to determine whether the use of a CAIV package having a Level III type of interactivity, which utilizes "real life" experiments, can facilitate the students in achieving the following objectives:

1. Students upon observing linear motion will be able to use the mathematics of graphing in order to plot linear motion on a displacement versus time graph, a velocity versus time graph, and an acceleration versus time graph.
2. Students upon studying a graph of linear motion will be able to interpret and describe qualitatively and quantitatively the movement that has taken place in terms of displacement, velocity, and acceleration.

Basically, the object of this study was to determine whether the CAIV approach is viable in the teaching of the concept of linear motion in physics.

This chapter contains the following topics:

1. A summary of the results obtained in this study with reference to related research.

2. Conclusions from the findings in this study.
3. Implications as to the future of the CAIV approach in teaching.
4. Recommendations for further study.

SUMMARY OF RESULTS

Seven students, selected according to the criteria listed in Table 2, covered a unit on graphical analysis of linear motion in physics by using the CAIV approach instead of attending regular class. The average time spent on the CAIV tutorial was 3.7 hours. An additional average of 2 hours were spent with the author reviewing the homework and answering questions on the concepts and thus, the average time needed to complete the unit on graphical analysis of linear motion using the CAIV approach was 5.7 hours. In a regular classroom this section takes approximately 12 hours (approximately 8 hours of teaching and 4 hours reviewing the homework and answering questions) and so it seems that it takes on the average half the time to cover the same material by using the CAIV approach. At times, students' homework/questions were dealt with individually and at other times a seminar type of session was held.

The mean pretest score of the students in the study was 41% and the mean posttest score was 52%. Therefore the percent gain between the pretest and the posttest was 27%.

The CAIV approach allowed flexibility in the time needed to follow the course. For example, two students were absent for one week during the study. One student broke his ankle and the other was ill. Upon returning, they were able to resume the CAIV tutorial at the place where they had left off.

The CAIV approach provided consistency in dealing with the tutorial. Everyone covered the material in the same manner, whether they were absent for a long period of time or for just one scheduled meeting.

This flexibility directs the students to work at their own pace. This characteristic was identified as a positive factor by the students. The pressure to finish quickly was not present and students had the option of reviewing the material whenever they wanted. The new vocabulary that was defined at the start of the tutorial was accessible to the student whenever it appeared throughout the tutorial. The student would click on the predefined term and s/he would be shown the definition. After having reviewed the definition, the student had the capability of returning to the place s/he had left in order to continue with his/her tutorial.

The students' perceptions on the use of this CAIV approach were very positive as was indicated in Table 6. The mean obtained as to the instructional design of the tutorial was 4.2, out of a maximum of 5, with a standard deviation of 0.6. The highest score (mean 4.7, standard deviation 0.5) was on the fact that it allowed the student an easy way to enter his/her results on the computer's screen. The lowest score (mean 3.6, standard deviation 0.8) was obtained on the question dealing with meaningful feedback. The feedback only informed the student of whether s/he was right (e.g. you'll be a physicist yet or jolly good show) or wrong (e.g. try again) with no other clue as to where their error might be located. All seven students gave a score of 4.0 to the question dealing with the fact that the CAIV approach maintained their interest. The question on meaningful animation obtained a high score (mean 4.4, standard deviation 0.5). Animation is important as stated by Rieber (1990) "... subjects in the animated visual condition took significantly less time to answer, suggesting that the animated presentations encouraged organization and aided subjects in reconstructing content retrieval." (p. 82)

A study done by Billings and Cobb (1992) on CAIV (they call it CAIVDI - computer-assisted interactive videodisc instruction) demonstrated that students have a strong and positive attititude towards this approach. In this present study, the students' attitude towards the use of the CAIV was very positive as may be seen in Table 7. The attitude mean was 4.2 out of a maximum of 5 and the standard deviation mean was 0.7. The highest score (mean 4.7, standard deviation 0.5) was on the statement that said "I enjoyed learning by the use of this method". Similar results were obtained by Marton (1990). Two statements obtained the lowest score (mean 4.0): a) "I prefer learning science by this method" (standard deviation 1.0); b) "I enjoyed using the buttons to activate different actions" (standard deviation 0.6). The second highest mean (4.3) was obtained on the statement that said "I was able to relate to the graphs which I constructed because the data (results) was gathered from "real life" situations (i.e. videotaped atheletes in motion). This result is important because it demonstrates that videodiscs used in the CAIV approach play an integral part in helping students relate physics concepts to "real life" stituations. Using images of "real life" situations of common events familiar to the student will help him/her in making a link between the physics concept and everyday motion. On interactive video instruction (IVI), Cronin & Cronin (1992) stated "IVI also allows learners to link specific visual images with specific text or graphic information in order to compare their understanding at various points in the presentation to video representations of others' understanding of these same issues." (p. 38).

The students were motivated by the CAIV approach. Several of the seven students were skipping other regular classes but they never skipped their scheduled time in this study. These students having volunteered may have been motivated (Colorado, 1988). The novelty effect was probably not a factor, because: a) the study took over a month to complete; b) most of the students had previous computer experience. As to their assigned homework, the pattern was similar to a regular class, sometimes it was done and at other times it wasn't.

One of the problems of this study was the multitude of disruptions in the schedule due to holidays and inservice days. The duration of the study would have been shorter but in a school term this scenerio exists at times. Therefore, the results obtained are realistic as to what would happen if this approach were used in a regular course.

Another problem was access to the hardware. If the student wanted extra time (other than the allotted time) on the tutorial, s/he would have to make special arrangements. Only a few students asked for extra time.

Several students stated that working alone was a disadvantage. One study done by Dalton, Hannafin and Hooper (1989) found that students working in pairs when using CAI lessons performed better than students working individually.

The author believes that the tutorial could be improved through:

1. The inclusion of more questions.
2. The inclusion of a greater variety of graphs covering many situations.
3. The provision of more precise/detailed feedback such that the student would be able to determine where s/he committed the error.
4. The utilization of sound in the feedback.
5. The inclusion of student progress reports
6. The inclusion of a capability for remembering the

student's location in the tutorial from the previous sitting.

CONCLUSIONS

The students using the CAIV package entitled *Motion* obtained comparable results to the students using the traditional approach in achieving the following objectives:

1. Students upon observing linear motion will be able to use the mathematics of graphing in order to plot linear motion on a displacement versus time graph, a velocity versus time graph, and an acceleration versus time graph.
2. Students upon studying a graph of linear motion will be able to interpret and describe qualitatively and quantitatively the movement that has taken place in terms of displacement, velocity, and acceleration.

According to this study, the benefits of the CAIV approach were:

1. Reduced learning time
2. Instructional consistency
3. Self-paced learning
4. Increased motivation
5. Use of "real life" situations in learning

6. Positive attitude towards learning

This study has found that the CAIV approach can achieve comparable results in less time than the traditional approach. Therefore, the CAIV approach is a viable method in the teaching of the concept of linear motion in physics.

IMPLICATIONS

The implications of this study are:

1. Students could have a greater choice in their approach to learning.
2. The student-teacher ratio might increase.
3. The time to complete courses will depend on the student's own ability.
4. Students will be at different levels in subject content.
5. The curriculum will change to reflect the new approaches.

In the future, the students could be given a choice on the way they would like to follow courses. The students will choose the approach that suits their learning style. According to Hoffer, Radke, and Lord (1992) "Multimedia presentations capable of delivering instruction using many different media would provide a potential mechanism to effectively address the different needs of a wide variety of learning styles." (p. 11). Some students need continuous direction and supervision by a teacher in order to successfully complete a course. Others, can work at their own pace using interactive technologies such as CAIV. The latter students would need the least supervision but the instructional design of the tutorial would have to be well done. Still other students might use both approaches and follow regular classes and the tutorial programs.

The student-teacher ratio would increase but it would be imperative for the CAIV or other interactive technology to be self contained. The programmed courses would have to include everything (e.g. tests, homework, explanations, labs, management of student's progress, etc.). The initial cost of implementing this new approach would be high due to the aquisition of hardware, software, and designated areas in the school facilitating this new approach. With time, the cost of educating the students would diminish due to four factors: a) the cost of the hardware decreases; b) more efficient time on task; c) decrease in teacher staffing; d) the hardware and software is durable and reusable, allowing the cost to be averaged out over many years.

The students will complete their courses according to their abilities and lifestyles. Some students have to work outside the school for one reason or another. Other students may have difficulty in comprehending the material and therefore need more time.

School grade levels as the term is used today will be eliminated.

Students following the CAIV approach or other interactive technology will complete courses at different times during the year thereby allowing them to proceed to the next level in the subject without having to finish a regular school year. Students will be at different levels in their subjects. For example, a student might be in level 5 in math but in level 3 in english. Levels would have to be defined.

RECOMMENDATIONS FOR FURTHER STUDY

There are many other studies that can be accomplished with this CAIV approach. One study could determine the effect of different types of control on the progress of the student. For example, should the student be forced to review a certain section after s/he has failed three times to answer a question or a quiz?

This study had one student working independently at a station. What would be the results if a pair of students were working at a station? Perhaps, a study should be carried out comparing the results of different numbers of students (one student, two students, and three students) working at a station. The students' interactions could be studied when they are in pairs or groups of three.

The effect of accessibility to the workstations could be studied. Students could be divided into two groups, one group could have access any time to the stations while the other group would have access according to a schedule.

This study used average students. A study could be undertaken to compare the results after having used the CAIV approach with above average students and below average students.

The CAIV approach is a fairly recent approach to learning. More research is needed in order to understand its effects and determine which features provide the best results (Colorado, 1988).

It appears that we are returning to the days of the ancient Greeks, where learning was achieved by the interaction of tutor and tutee. The only difference now is that everyone can benefit from this interaction.

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APPENDICES

APPENDIX A

AN EXAMPLE OF PERFORMANCE OBJECTIVES

TOPIC: Transferring observed linear motion onto graphs.

INSTRUCTIONAL GOAL: The student upon observing linear motion will be able to use the mathematics of graphing in order to plot the linear motion on a distance versus time graph.

STEP 1 - CONSTRUCT A DATA TABLE WITH THE FOLLOWING THREE COLUMNS: POSITION NUMBER, TIME & DISTANCE.

SUBSKILL	**PERFORMANCE OBJECTIVE**
1.1 Draw vertical & horizontal lines	1.1 Given a straight edge (ruler), the student using a pencil or pen draws vertical and horizontal lines on a sheet of paper.
1.2 Define a data table	1.2 In your own words, write a definition of a data table. The definition must include that the observed information must be placed in an organized manner such that the data can be easily understood from it.
1.3 Draw a data table	1.3 Given a ruler and several items of information which will be recorded for each case, draw a data table such that the data is recorded under the columns of each item.
1.0 Construct a data table having the following three columns: position number, time & distance.	1.0 The student is given the following three items: position number, time and distance. The student draws a data table having three columns which are entitled with the above items and allowing for ten sets of readings.

STEP 2 - DETERMINE THE DISTANCE BETWEEN THE REFERENCE POSITION AND A SELECTED POSITION.

SUBSKILL	**PERFORMANCE OBJECTIVE**
2.1 Measure distances with a ruler or tape measure to the nearest ±0.1 of the unit used.	2.1 Given two points on a picture, a screen or on the ground, measure the distance between the two points to the nearest ±0.1 of the unit used. The student uses a ruler or a tape measure.
2.2 Determine whether a picture of a real-life event is used or the real-life event itself.	2.2 Given a picture of a real-life event and brought to the real-life event, the student has to identify which one is the picture and which one is the real-life event.
2.3 Identify the real distance between markers.	2.3 Given a picture of a real-life event, the student has to identify the real distance between markers by looking at the legend or scale on the picture.
2.4 Measure the distance between the markers to the nearest millimeter on the picture.	2.4 Given a picture of a real-life event, the student has to measure using a ruler the distance between the markers to the nearest millimeter.
2.5 Calculate the conversion ratio for the picture of the real-life event.	2.5 Given a picture of a real-life event, the student will calculate the conversion ratio by dividing the real distance between the markers by the distance measured on the picture between the markers.
2.6 Measure the distance between two positions on the picture.	2.6 Given a picture of a real-life event, the student will measure the distance between two positions on the picture by using a ruler. The distance will be measured to the nearest millimeter.

2.7 Convert the measured distance from the picture into the real-life distance.	2.7 Given a measured distance from a picture, the student will convert the measured distance into a real-life distance by multiplying the measured distance by the conversion ratio.
2.8 Measure the distance between two points in real-life to the centimeter.	2.8 Given two points in a real-life case, the student measures the distance between the two points to the nearest centimeter by using a tape measure.
2.0 Determine the distance between the reference position and the selected position.	2.0 Given a reference point and a selected point, the student will determine the distance to the nearest ±0.1 of the unit used between the two given points.

STEP 3 - WRITE IN THE DATA TABLE THE POSITION NUMBER, THE DISTANCES AND THE CORRESPONDING TIMES FOR EACH OF THE SELECTED POINTS.

SUBSKILL	**PERFORMANCE OBJECTIVE**
3.0 Write in the data table the distances and the corresponding times for each of the position numbers.	3.0 The student is given a data table with the following items to be recorded: the position number, the time and the distance.

STEP 4 - DRAW A DISTANCE VERSUS TIME GRAPH

SUBSKILL	**PERFORMANCE OBJECTIVE**
4.1 Draw two lines perpendicular to each other.	4.1 Given a ruler and a sheet of graph paper, the student will draw two lines perpendicular to each ather.
4.2 Position and label the axis into the proper units.	4.2 Given two drawn perpendicular lines on a graph paper, the student will label the axes into the proper units such that the time is on the horizontal axis and

	the distance is on the vertical axis.
4.3 Divide the axes into the appropriate divisions.	4.3 The student is given two drawn perpendicular lines on a graph paper with the axes labelled. The student is also given ten points to be placed in the graph. The student divides the axes into the appropriate divisions such that the points can be placed on the graph.
4.0 Draw a distance versus time graph.	4.0 The student is given ten selected positions from a data table in which for each position the times and the distances were recorded. The student draws a distance versus time graph such that the ten points can be placed on the graph.

STEP 5 - PLOT THE POINTS ON THE DISTANCE VERSUS TIME GRAPH.

SUBSKILL	PERFORMANCE OBJECTIVE
5.1 Define coordinate	5.1 In your own words, write a definition of a coordinate. The definition must include that the coordinate is any of a set of magnitudes by means of which the position of a point, line, or angle is determined with refererence to fixed elements.
5.2 Define abscissa	5.2 In your own words, write a definition of an abscissa. The definition must include that the abscissa is the distance of any point from the Y-axis of ordinates in a coordinate system, measured on a line parallel to the X-axis.
5.3 Define ordinate	5.3 In your own words, write a definition of an ordinate. The definition must include that the

			ordinate is the distance of any point from the X-axis, measured on a line parallel to the Y-axis in a coordinate system.
5.4	Plot coordinates on a graph	5.4	The student is given coordinates and an X-Y graph. The student has to plot the coordinates on the X-Y graph.
5.0	Plot the points on the distance versus time graph	5.0	The student is given a data table with the following three columns: position number, distance, and time. For each position number plot the corresponding coordinates having distance (abscissa) and time (ordinate) on the distance versus time graph.

STEP 6 - DRAW THE BEST FIT LINE THROUGH THE POINTS

6.0	Draw the best fit line through the points on the distance versus time graph.	6.0	Given a graph with points on it, the student has to draw a best fit line (a straight line or a curved line) through the points.

APPENDIX B

AN EXAMPLE OF HOMEWORK EXERCISES

PART 2: DEFINITIONS

PROBLEMS

1. Organize the following quantities into two groups: vector quantities and scalar quantities. Also identify the physical quantity that each measures. For example, the quantity sixteen years (16 a) is a scalar quantity since it measures time and has no direction.

   50 km/h, 6 km[N], 2000 kg/m^3, 6 centuries, 800 kg, 1.0 kg/week, 20 m/s[S], 400 N[down]

2. Compare a scalar quantity and a vector quantity. How are they the same? How are they different?

3. Choose a suitable scale and draw the following position vectors:
   a) 5 dm[N] of A
   b) 10 km[W] of home

4. Draw vectors to represent the following displacements. Use an appropriate scale and reference co-ordinates.
   a) 4 m[N]
   b) 8 km[E]

5. Use a number line to determine the displacement for the following changes in position:
   a) -4 km to +5 km
   b) -4 km to -9 km
   c) +5 km to +11 km
   d) +3 km to -5 km to +7 km
   e) +8 km to -8 km
   f) +2 km to -3 km to +3 km
   g) 4 km[E] to 10 km[W]
   h) 23 km[W] to 2 km[W]
   (+9 km, -5 km, +6 km, +4 km, -16 km, +1 km, 14 km[W], 21 km[E])

6. For each of the problems in number 5 question, determine the distance travelled.
   (9 km, 5 km, 6 km, 20 km, 16 km, 11 km, 14 km, 21 km)

7. What is the speed of a train that travels a distance of 480 km in 8.0 h?
   (60 km/h)

8. An ant moves a distance of 39.4 cm in 7.3 s. What is its speed?
   (5.4 cm/s)

9. A goalkeeper for a hockey team has a reaction time of 0.40 s. A puck travelling at 25 m/s bounces off an opposing player's pads without slowing down. How far away must this occur to give the goalkeeper a chance to make a save? (10 m)

10. A tourist travelling along a straight section of the TransCanada Highway late at night has the car set on cruise control. At 11:30 p.m., he notices a sign which reads "Calgary 250 km". At midnight he notices another sign which reads "Calgary 190 km". If the tourist is located directly east of Calgary on both occasions, find:
    a) his displacement for the half hour interval stated,
    b) his velocity, and
    c) his speed. (60 km[W],120 km/h[W], 120 km/h)

11. A centipede crawled 12 cm along a log before lunch and 16 cm after lunch. What distance did the centipede crawl that day? (28 cm)

12. A grizzly bear went searching for honey. She walked due east for 6 km and then due west for 4 km. Calculate a) the total distance travelled, b) the resultant displacement. (10 km, 2 km[E])

13. What is the total displacement of two trips made by a forest ranger, one of 12 km[N], and the other of 15 km[S]? (3 km[S])

14. What is the velocity of an airplane that experiences a displacement of 580 m[N] in 2.5 s? (2.3×10^2 m/s[N])

15. A car has a velocity of 105 km/h[N]. What is its displacement if it travels at this velocity for 2.5 h? (2.6×10^2 km[N])

16. What velocity is required for a truck moving along the highway to experience a displacement of 400 m[W] in a time of 20 s? Express your answer in metres per second and in kilometres per hour. (20 m/s[W], or 72 km/h[W])

17. How long would it take a dolphin swimming at 8.0 m/s[E] to travel 208 m[E]? (26 s)

18. Distinguish between period and frequency.

19. A pendulum completes 120 vibrations in 30 s. Calculate a) its period, b) its frequency. (0.25 s, 4 Hz)

20. A bell clapper hits a gong 360 times in 6.0 s. How long does it take to hit the gong 12 times? (0.20 s)

21. The frequency of a recording timer is 40 Hz. Calculate
    a) the period of the recording timer.
    b) the time for the recording timer to complete 100 vibrations.
    c) the number of vibrations in 10 s.

(0.025 s, 2.5 s, 4.0 x 10^2 vibrations)

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APPENDIX C

CONSENT FORM TO PARTICIPATE IN A RESEARCH STUDY

CONSENT FORM TO PARTICIPATE IN A RESEARCH STUDY

January 25, 1991

Dear Parents,

My name is Mr. V. Pasek. Probably some of you already know that I am a regular science teacher at Archbishop O'Leary High School. This school year I obtained a sabbatical for the duration of five months. Since September, 1990, I have been working on a Master's thesis and have developed a computer based module which can be used by students on an individual basis to learn several concepts in physics 10. I am asking for your permission to allow your son/daughter to participate in a research study to test the module.

The following is a brief summary of the research entitled *A case study: The use of a computer assisted interactive videodisc in the teaching of the concept of linear motion in physics.*

This research is a study on the use of a computer assisted interactive videodisc (CAIV)in the teaching of the concept of linear motion in physics. Basically, a level III type interactive videodisc program will be produced and it will be used by nine students enrolled in the Physics 10 program at Archbishop O'Leary High School in Edmonton. These nine selected students will be removed from their regular physics class and they will cover the material on the graphical analysis of linear motion by using the developed program while the other students will cover the same material in class with the teacher. The nine students will be administered a pretest and a posttest. The pretest will determine what the students know prior to the start of the program and the posttest will determine if the objectives were met. Descriptive analysis and analysis of variance would be used to analyze the results. Positive results will mean that this program would be an alternate method of teaching graphical analysis of linear motion.

The names of the students will be kept confidential because the results will be treated collectively in the write up of the research.Special provision has been made to ensure that students who participate in this research will not be placed at any disadvantage as far as the material covered.

The students participating in this study will be released from their regular physics 10 class but they will have a choice on that day as to when they wish to follow the above program. They have a choice of the following three blocks of the day: 1) before school starts in the morning, 2) during lunch hour, or 3) right after school. These blocks will be of a half hour duration.I will be present in the room while the student is following the CAIV program. Homework will also be assigned and corrected.

This study is expected to take place between February 11,1991 and March 11,1991. The student can at any time pull out of the program and will not suffer any consequences due to his or her decision to do so.

If there are any questions you wish to ask, feel free to contact me at the following numbers: 459-5306 (home), 476 -6251 (school). Thank you for your cooperation.

Sincerely yours

Vlad Pasek
Teacher

PLEASE COMPLETE THE CONSENT FORM BELOW THEN RETURN THE WHOLE LETTER AS SOON AS POSSIBLE

PARENT- Please complete the folowing

I give permission for my son/daughter ____________________ to partake in the above study and I understood the above statements.

____________________________ date:____________________
signature of parent/guardian

STUDENT- Please complete the following

I, __________________________, understood the above statements.

___________________________ date:____________________
signature of student

I will follow the program in block _________. (please choose one)
a) in the morning before school starts b) during lunch c) immediately after school ends

APPENDIX D

PRETEST/POSTTEST

Physics 10 Test

Graphical Analysis of Linear Motion

Instructions: This test is made up of 36 multiple choice questions which you answer on the provided answer sheet at the back of the test. All you need is a pencil, a ruler, and a calculator.

1. How is the vector quantity different from a scalar quantity? A vector quantity has

   a) a unit, but a scalar quantity does not.
   b) a direction, but a scalar quantity does not.
   c) a numeral, but a scalar quantity does not.
   d) a size, but a scalar quantity does not.

2. Tommy decided to run away from home. He walked 5.0 km [E], then 3.0 km [W] followed by 6.0 km [E]. What is Tommy's final position from home?

   a) 2.0 km [E]
   b) 4.0 km [W]
   c) 8.0 km [E]
   d) 14 km [E]

3. A tape from a laboratory experiment shown in Figure 1. The dots were made by a hammer having a constant frequency of 24 Hz (cycles/second). The total elapsed time between dot U and dot Z is

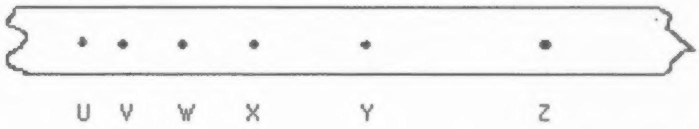


Fig. 1

   a) 5.0 s
   b) 4.8 s
   c) 0.25 s
   d) 0.21 s

4. Which of the following is a vector quantity?

   a) speed
   b) time
   c) displacement
   d) north

5. According to the following number line, what is the displacement of a body at point **B** with respect to point **A** ?

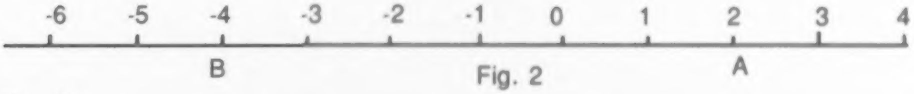


Fig. 2

a) 2
b) -2
c) -4
d) -6

6. Which of the following statments is **TRUE** for the line shown in Fig 3?

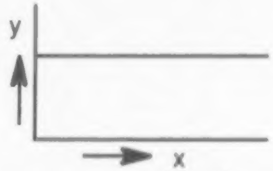


Fig. 3

a) the slope of the line is undefined.
b) the slope of the line is zero.
c) the slope of the line is positive.
d) the slope of the line is negative.

7. The following diagram represents a ticker-timer record produced by a cart travelling with a constant speed, v.

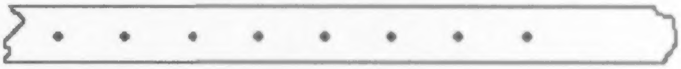
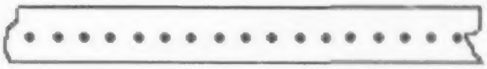


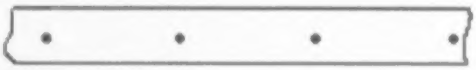
Fig. 4

Assume that the frequency of the timer does not change. Which one of the following diagrams best represents a record of a cart travelling with a constant speed, 2v?

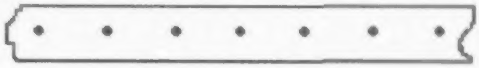
a)



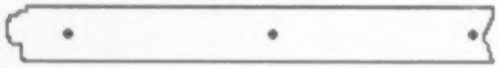
b)



c)



d)



8. The tape from a laboratory experiment using a recording timer has the appearance shown underneath. Which graph could be the position-time graph for an object moving to the right?

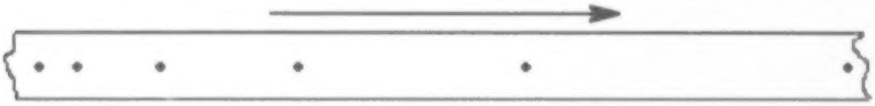
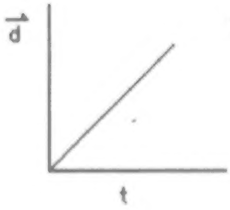
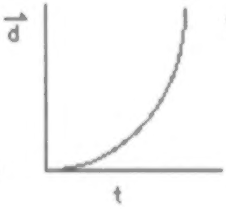


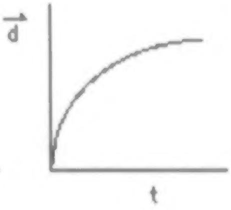
Fig. 5



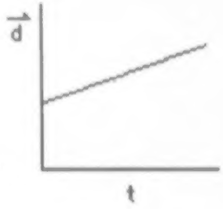
a)



b)



c)



d)

9. In Figure 6, the distance moved by a cart in successive seconds is given by the spacing between dots.

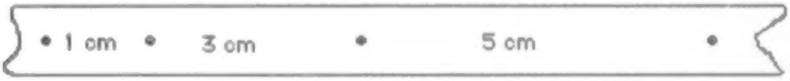


Fig. 6

What is the average speed of the cart for the three seconds?

a) 2.0 cm/s
b) 2.5 cm/s
c) 3.0 cm/s
d) 4.5 cm/s

Study the information below in Figure 7; then complete questions 10 to 11

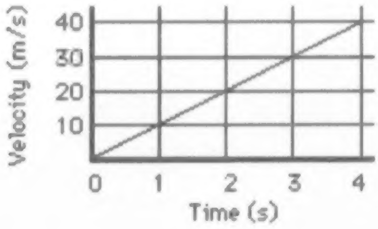


Fig. 7

10. At t = 2.5 s, the velocity of the car is

a) 10 m/s
b) 20 m/s
c) 25 m/s
d) 35 m/s

11. The rate at which the velocity is changing as a function of time is obtained by calculating the value of the

a) slope
b) independent variable
c) dependent variable
d) intercept

Study the graph in Figure 8; then complete questions 12 to 13.

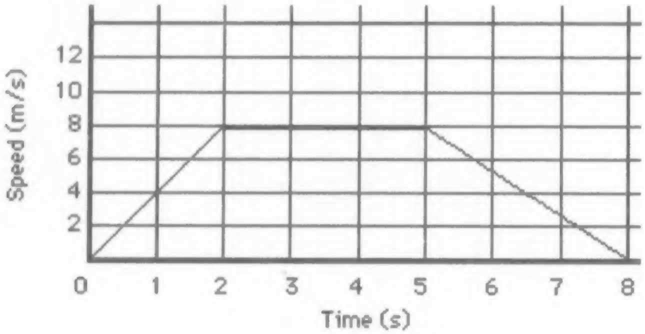


Fig. 8

A car starting from rest accelerates as shown in the graph.

12. The period of time during which the speed of the car is constant is

a) 0 s - 2 s
b) 0 s - 6 s
c) 2 s -5 s
d) 5 s - 8 s

13. The car is slowing down during the time period

a) 0 s - 2 s
b) 2 s - 4 s
c) 4 s - 5 s
d) 5 s - 8 s

14. The speed-time graph for a body is shown in Figure 9. The distance travelled by the body in 7.0 s will be

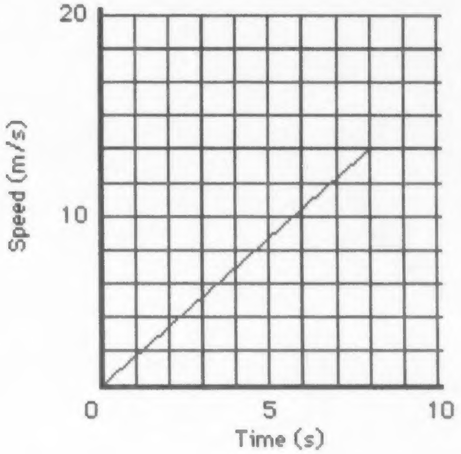


Fig. 9

a) 112 m
b) 84 m
c) 42 m
d) 56 m

Study the information in Figure 10; then complete questions 15 and 16

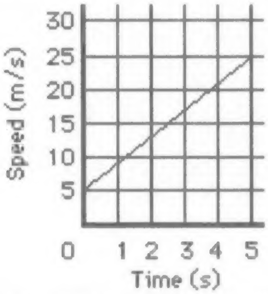


Fig. 10

The graph in Figure 10 represents the various speeds of an automobile travelling along a straight road for 5 s.

15. The average speed of the car from t = 0 s to t = 5 s is

a) 5 m/s
b) 10 m/s
c) 15 m/s
d) 25 m/s

16. The distance travelled by the car in 5 s from t = 0 s to t =5 s is

a) 25 m
b) 50 m
c) 75 m
d) 125 m

Questions 17 to 19 refer to Figure 11 which represents the velocity of a cart moving in a straight line over a five second period.

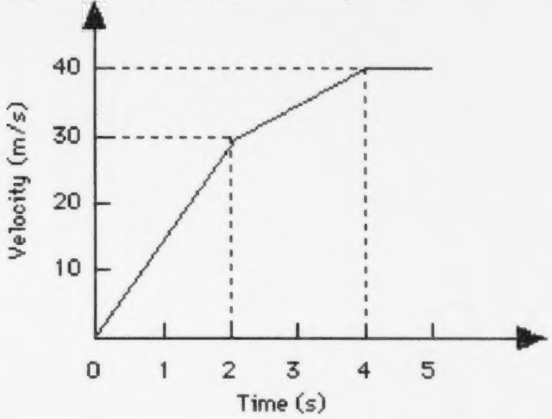


Fig. 11

17. How many meters has the object travelled after two seconds?

a) 15 m
b) 30 m
c) 45 m
d) 60 m

18. How many meters has the object travelled after four seconds?

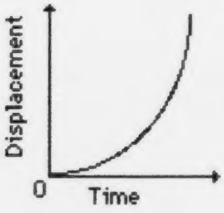
a) 85 m
b) 100 m
c) 110 m
d) 130 m

19. What is the magnitude of the acceleration of the object at the time three seconds after starting?

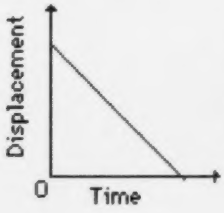
a) 5 m/s^2
b) 10 m/s^2
c) 20 m/s^2
d) unable to be determined from the information given

20. A train decelerates at a constant rate during a period commencing at $t = 0$. Which graph represents the displacement of the train?

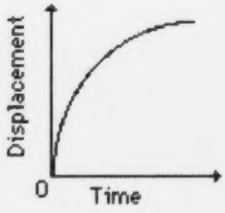
a)



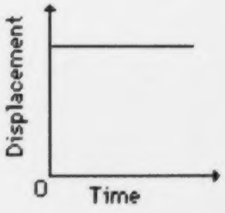
b)



c)



d)



21. The acceleration -time graph for a cart is shown in figure 12.

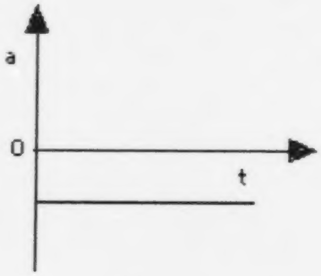
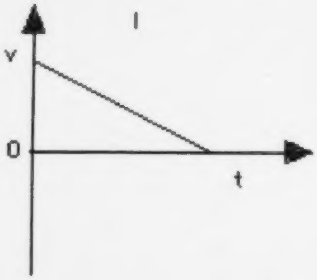
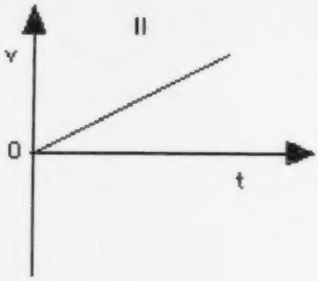
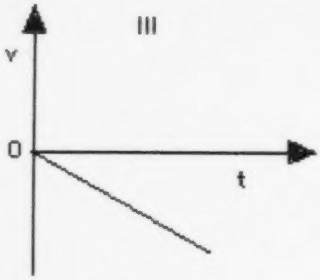


Fig. 12

Which of the following diagrams represents the velocty-time graph describing the cart's motion?

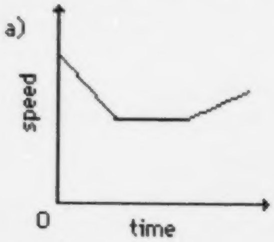


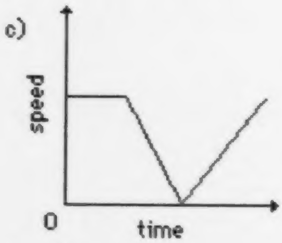


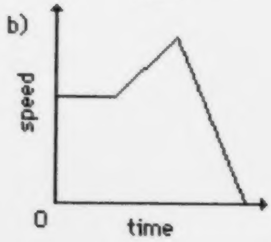


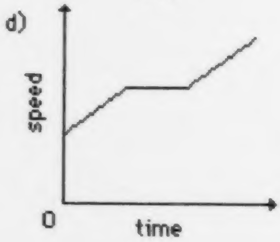
a) I only
b) II only
c) both II and III
d) both I and III

22. Which graph represents the motion of a car's uniform deceleration to a constant speed followed by uniform acceleration?









Study Figure 13 and answer questions 23 to 26

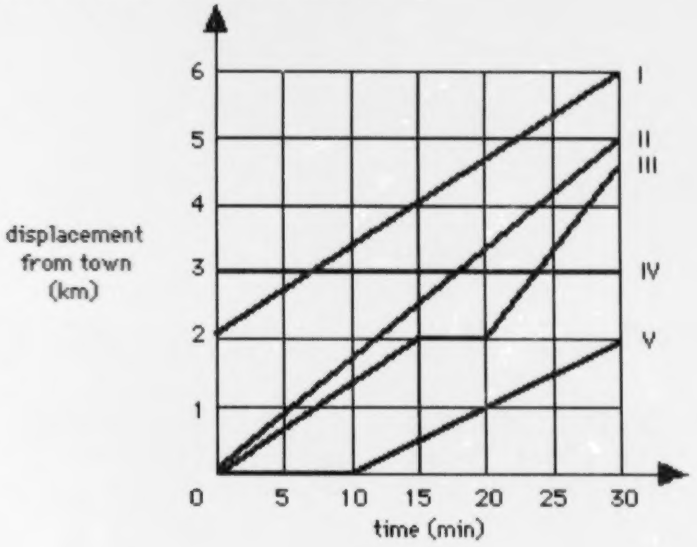


Figure 13

The graph above shows the varying positions of five cyclists (I - V) recorded over a 30 minute period on a straight road leading from a town. The town was taken as the zero point for displacement.

23. Which cyclist was the last to leave the town?

a) I
b) III
c) IV
d) V

24. Which cyclist attained the greatest speed during the 30 minute period recorded?

a) I
b) III
c) IV
d) V

25. Which cyclists were stationary at some time during the interval between 5 and 25 minutes?

a) III and IV only
b) IV and V only
c) III and V only
d) III, IV and V only

26. Which one of the following cyclists was **not** at the town at the start of the 30 minute period?

a) II
b) III
c) IV
d) V

Study Figure 14 for questions 27 to 28

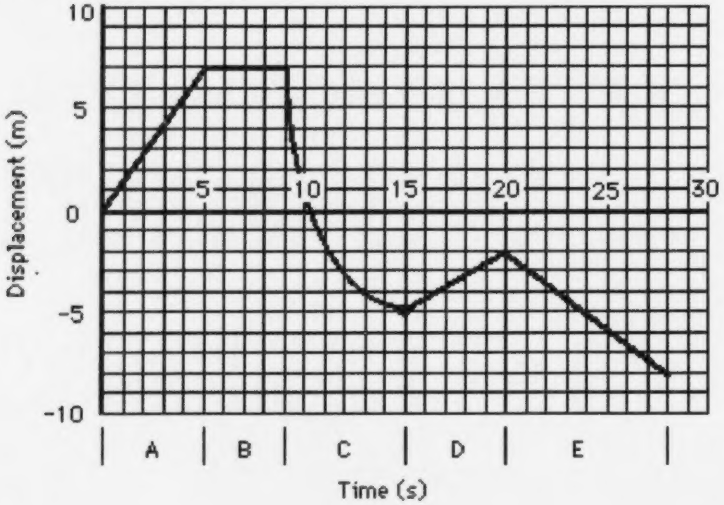


Figure 14

An object is moving along a straight line. The graph shows its displacement from the starting point as a function of time. Various sections of the graph are identified by the letters A, B, C, D, and E.

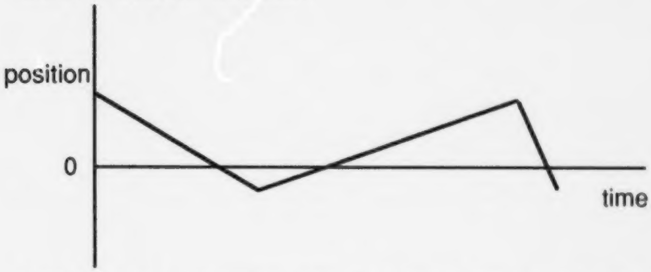
27. Which section of the graph represents a constant velocity of +3/5 m/s?

a) A
b) C
c) D
d) E

28. What was the instantaneous velocity of the object at the end of the eighth second?

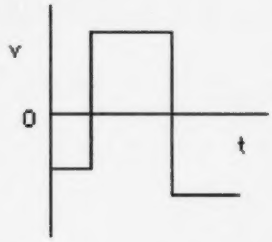
a) 7 m/s
b) 7/8 m/s
c) -7/8 m/s
d) 0 m/s

29. The following graph of position versus time is for the motion of an object travelling along a straight line path:

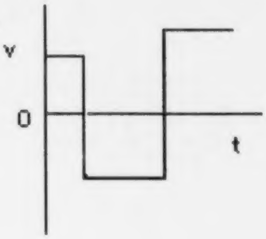


Which of the following velocity versus time graphs best represents this motion?

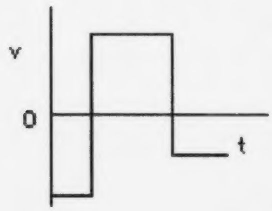
a)



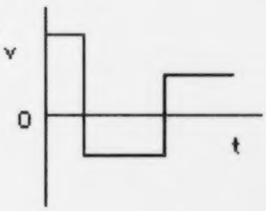
c)



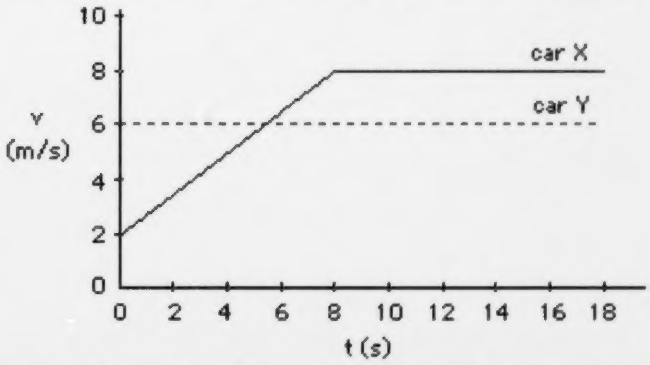
b)



d)



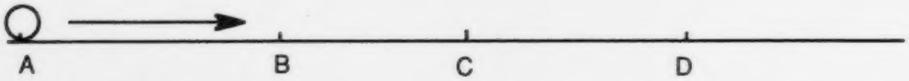
30. The velocity-time graph below records the motion of two cars, **X** and **Y**.



During the first 12 seconds of the motion recorded by the graphs:

a) car **X**'s displacement was 2 m greater than car **Y**'s.
b) car **X**'s displacement was 9 m greater than car **Y**'s.
c) car **X**'s displacement was 3 m greater than car **Y**'s
d) car **X**'s displacement was equal to car **Y**'s

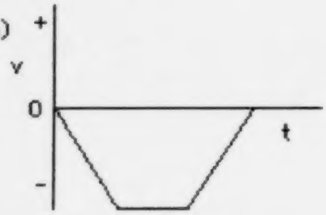
31. A ball rolls along a track as diagrammed below.



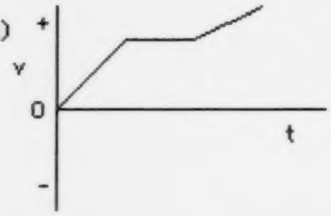
The motion of the ball is as follows: Starting from rest at point **A** the ball moves to point **B** with a constant acceleration, then at point **B** the acceleration suddenly drops to zero and stays that way until the ball reaches point **C** where the acceleration suddenly jumps to the same value as berween **A** and **B** but in the opposite direction and remains at that value until it reaches point **D**.

Which of the following velocity - time graphs best describes this motion?

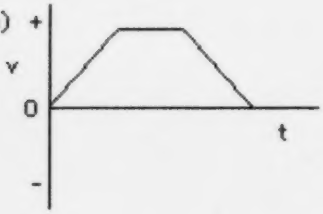
a)



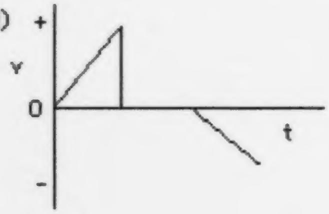
c)



b)



d)



Study the information in Figure 15; then complete questions 32 to 34

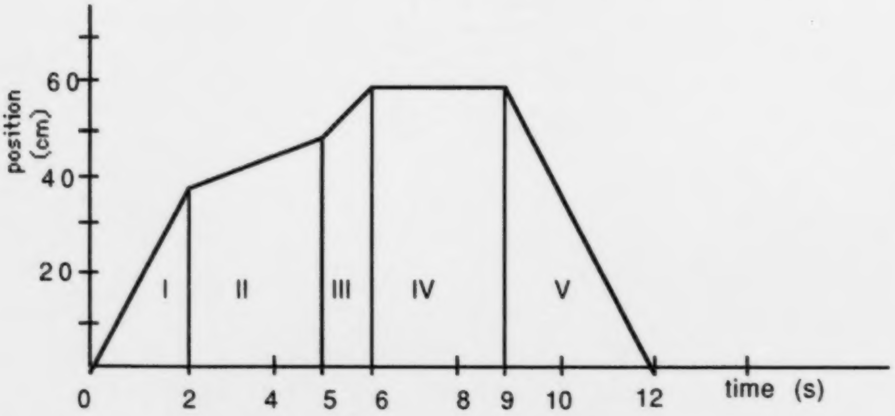


Figure 15

The above graph represents the motion of an object by means of a position-time graph

32. During which interval did the object cover the greatest distance?

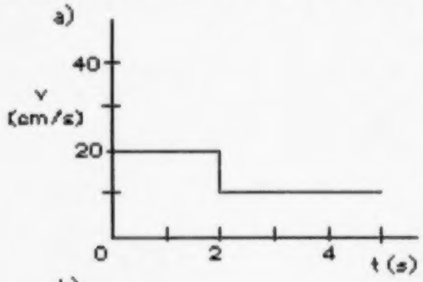
a) I
b) II
c) IV
d) V

33. What is the instantaneous velocity at the 10 second mark?

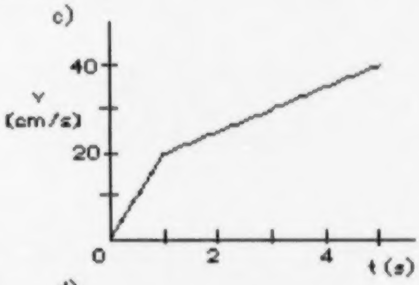
a) -4 cm/s
b) 10 cm/s
c) -10 cm/s
d) -20 cm/s

34. Which of the following graphs best represents the velocity of the object as a function of time during the first 5 seconds?

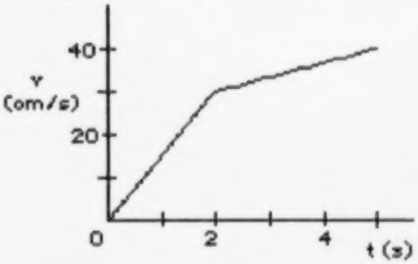
a)



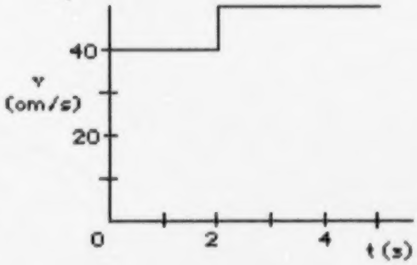
c)



b)

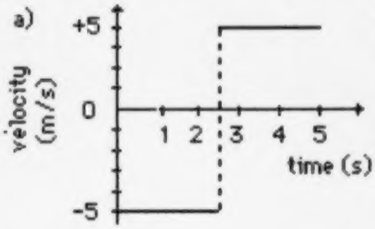


d)

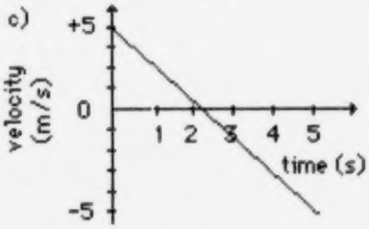


35. The following velocity-time graphs relate to 4 objects in straight line motion. Which object has the greatest displacement during the time interval from t = 0 s to t = 5 s?

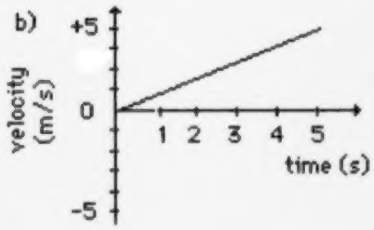
a)



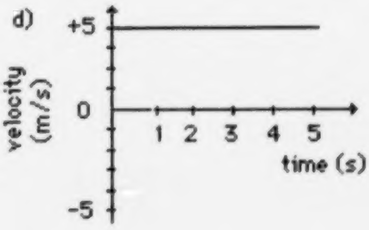
c)



b)



d)

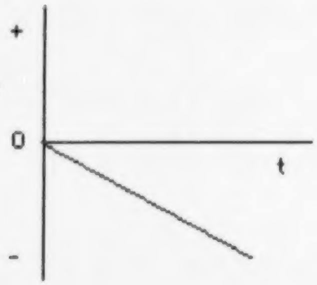


36. The table below gives the position of an object at 1.00 s intervals.

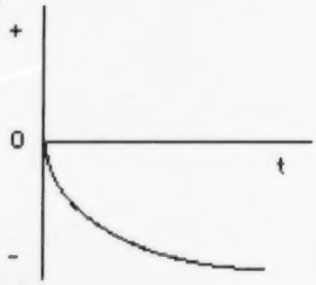
Time	Displacement
0.00 s	0.00 cm
1.00 s	- 2.00 cm
2.00 s	- 4.00 cm
3.00 s	- 6.00 cm

The velocity - time graph representing this motion would look like

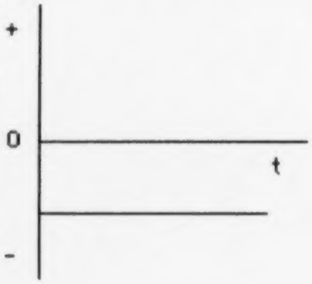
a)



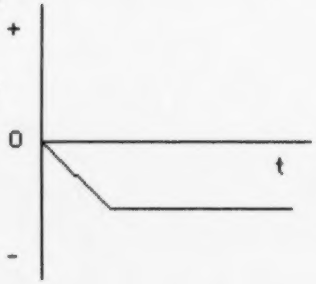
c)



b)



d)



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APPENDIX E

QUESTIONNAIRE

QUESTIONNAIRE

Questionnaire on the Instructional Design and Attitudes towards the Computer Assisted Interactive Videodisc in the Teaching of the Graphical Analysis of Linear Motion in Physics.

Instructions: Read the following questions and then circle one of the five possible responses.

Instructional Design:

The tutorial on the graphical analysis of linear motion that I just completed:

1. Held my attention

Strongly agree Agree Undecided Disagree Strongly disagree

2. Maintained my interest

Strongly agree Agree Undecided Disagree Strongly disagree

3. Provided an easy way to enter my results on the computer's screen

Strongly agree Agree Undecided Disagree Strongly disagree

4. Provided clear directions

Strongly agree Agree Undecided Disagree Strongly disagree

5. Provided meaningful feedback

Strongly agree Agree Undecided Disagree Strongly disagree

6. Allowed me to control the pace of learning

Strongly agree Agree Undecided Disagree Strongly disagree

7. Provided meaningful animation

Strongly agree Agree Undecided Disagree Strongly disagree

8. The order that the material was presented was well done

Strongly agree Agree Undecided Disagree Strongly disagree

9. The diagrams were clearly drawn

Strongly agree Agree Undecided Disagree Strongly disagree

10. The diagrams were clearly labeled

Strongly agree Agree Undecided Disagree Strongly disagree

11. The homework related well to the tutorial

Strongly agree Agree Undecided Disagree Strongly disagree

Attitudes

1. I enjoyed learning by the use of this method

Strongly agree Agree Undecided Disagree Strongly disagree

2. I prefer learning science by this method

Strongly agree Agree Undecided Disagree Strongly disagree

3. I enjoyed doing the labs in this manner

Strongly agree Agree Undecided Disagree Strongly disagree

4. I believe this is an effective way of learning science

Strongly agree Agree Undecided Disagree Strongly disagree

5. I was better able to relate to the graphs which I constructed because the data(results) was gathered from "real life" situations (i.e. videotaped atheletes in motion)

Strongly agree Agree Undecided Disagree Strongly disagree

6. I enjoyed using the buttons to activate different actions

Strongly agree Agree Undecided Disagree Strongly disagree

Other Comments

1. Some of the advantages using this method are ______________________
____
____
____
____
____
____.

2. Some of the disadvantages using this method are ____________________
____
____
____
____
____
____.

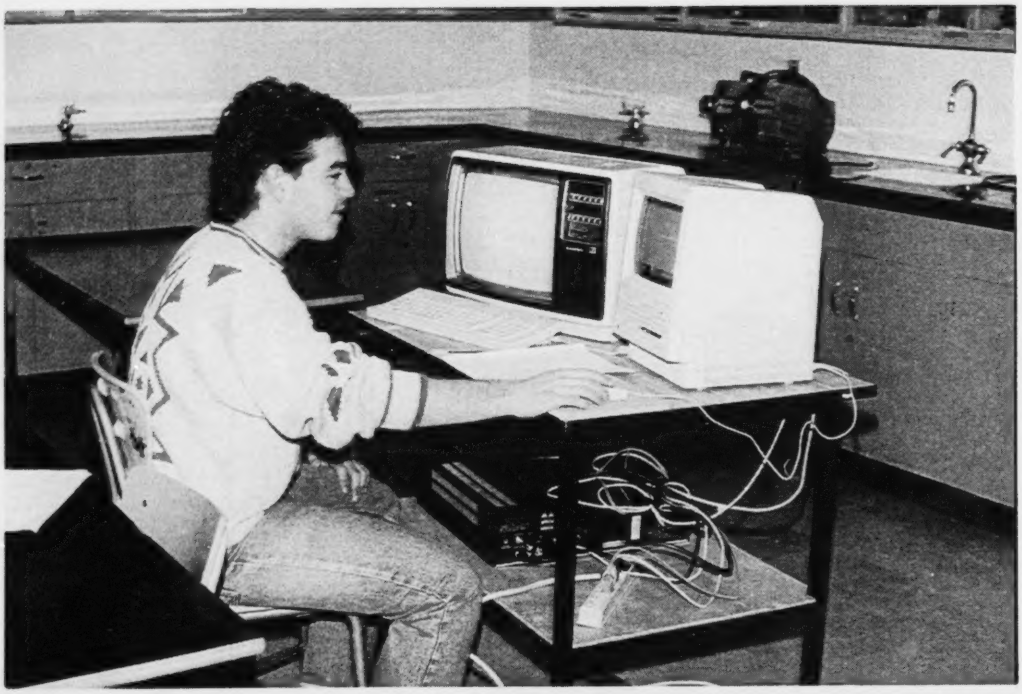
3. How can this tutorial be improved? ______________________________
____
____
____
____
____
____.

4. In comparison to a regular course, I worked

Harder the same less

APPENDIX F

PHOTOGRAPHS



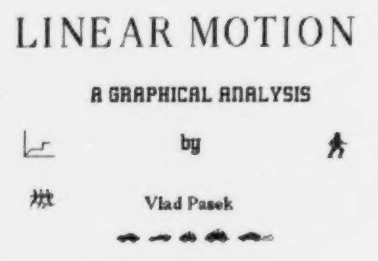
Student working on the CAIV

Student working on the data

APPENDIX G

THE MOTION STACK

Motion

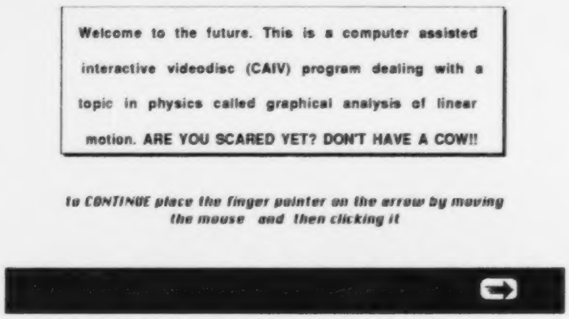


LINEAR MOTION

A GRAPHICAL ANALYSIS

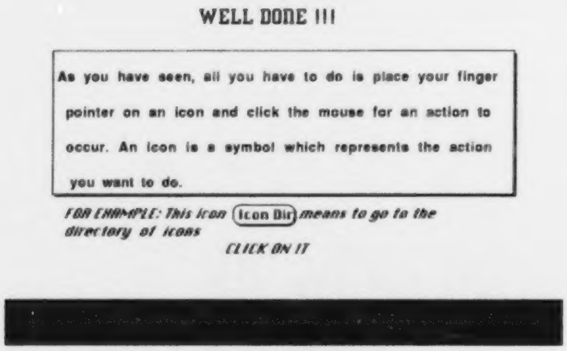
by

Vlad Pasek



Welcome to the future. This is a computer assisted interactive videodisc (CAIV) program dealing with a topic in physics called graphical analysis of linear motion. ARE YOU SCARED YET? DON'T HAVE A COW!!

to CONTINUE place the finger pointer on the arrow by moving the mouse and then clicking it

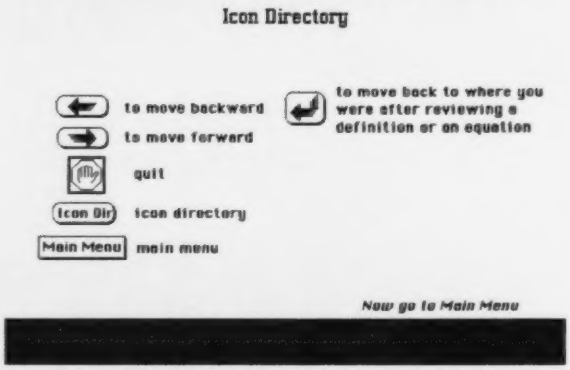


WELL DONE !!!

As you have seen, all you have to do is place your finger pointer on an icon and click the mouse for an action to occur. An icon is a symbol which represents the action you want to do.

FOR EXAMPLE: This icon Icon Dir *means to go to the directory of icons*

CLICK ON IT



Icon Directory

to move backward

to move forward

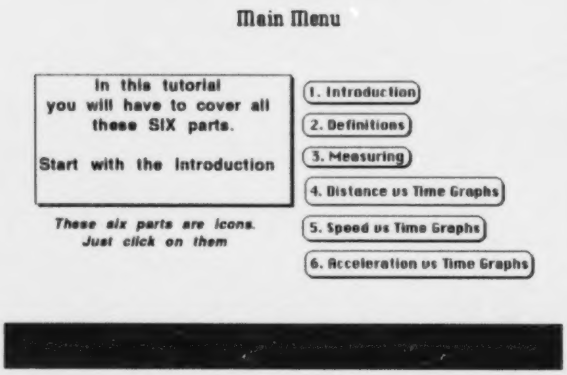
quit

Icon Dir — icon directory

Main Menu — main menu

to move back to where you were after reviewing a definition or an equation

Now go to Main Menu



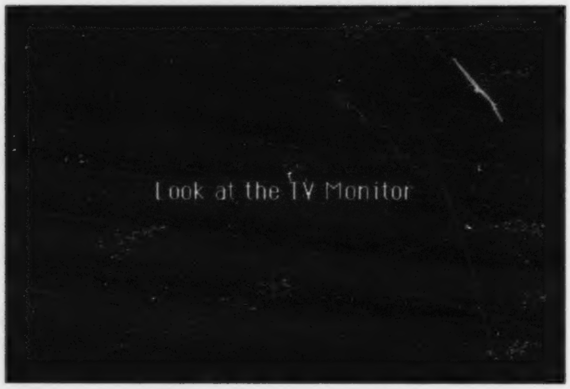
Main Menu

In this tutorial you will have to cover all these SIX parts.

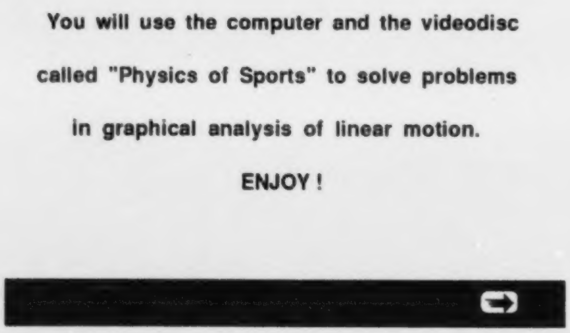
Start with the Introduction

These six parts are icons. Just click on them

1. Introduction
2. Definitions
3. Measuring
4. Distance vs Time Graphs
5. Speed vs Time Graphs
6. Acceleration vs Time Graphs

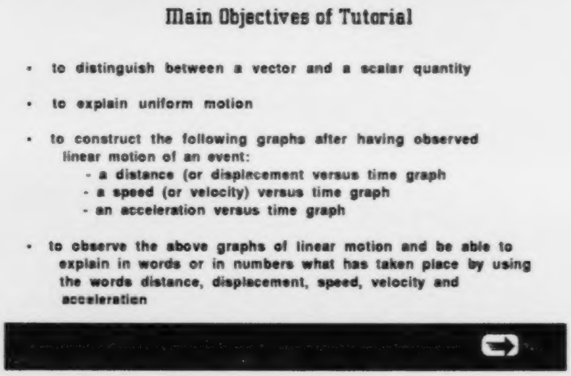


Look at the TV Monitor



You will use the computer and the videodisc called "Physics of Sports" to solve problems in graphical analysis of linear motion.

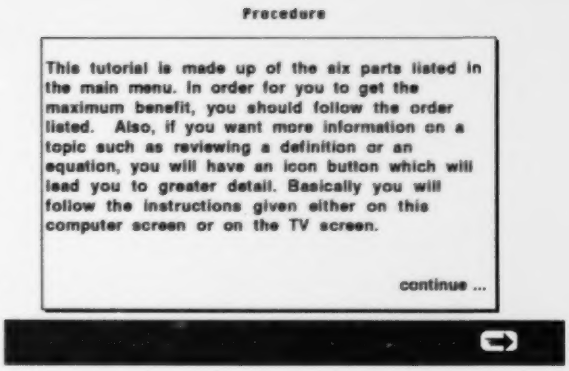
ENJOY !



Main Objectives of Tutorial

- to distinguish between a vector and a scalar quantity
- to explain uniform motion
- to construct the following graphs after having observed linear motion of an event:
  - a distance (or displacement versus time graph
  - a speed (or velocity) versus time graph
  - an acceleration versus time graph
- to observe the above graphs of linear motion and be able to explain in words or in numbers what has taken place by using the words distance, displacement, speed, velocity and acceleration

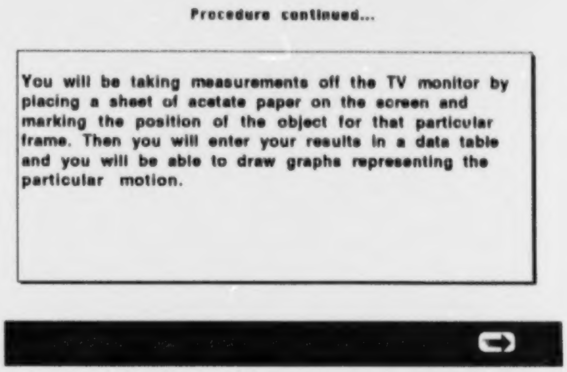
Motion



Procedure

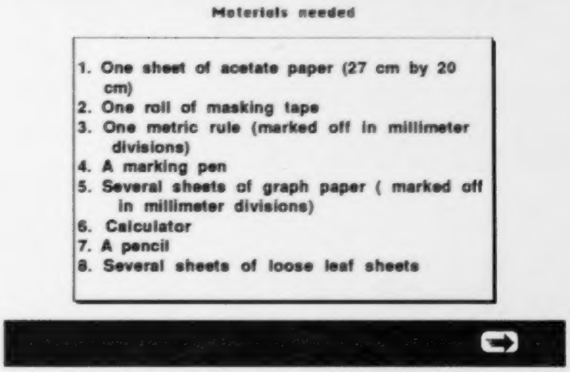
This tutorial is made up of the six parts listed in the main menu. In order for you to get the maximum benefit, you should follow the order listed. Also, if you want more information on a topic such as reviewing a definition or an equation, you will have an icon button which will lead you to greater detail. Basically you will follow the instructions given either on this computer screen or on the TV screen.

continue ...



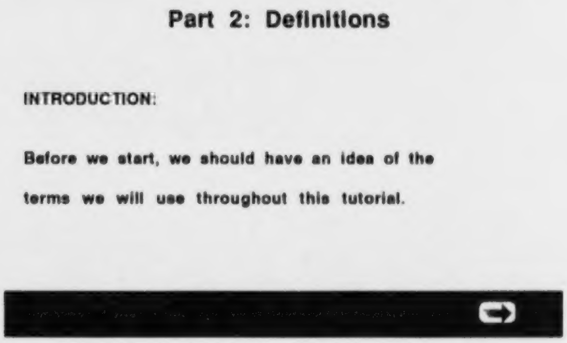
Procedure continued...

You will be taking measurements off the TV monitor by placing a sheet of acetate paper on the screen and marking the position of the object for that particular frame. Then you will enter your results in a data table and you will be able to draw graphs representing the particular motion.



Materials needed

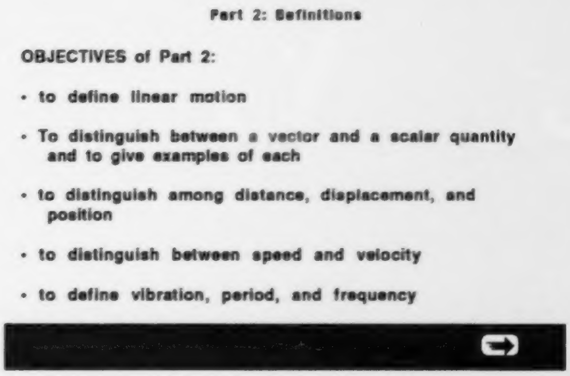
1. One sheet of acetate paper (27 cm by 20 cm)
2. One roll of masking tape
3. One metric rule (marked off in millimeter divisions)
4. A marking pen
5. Several sheets of graph paper (marked off in millimeter divisions)
6. Calculator
7. A pencil
8. Several sheets of loose leaf sheets



Part 2: Definitions

INTRODUCTION:

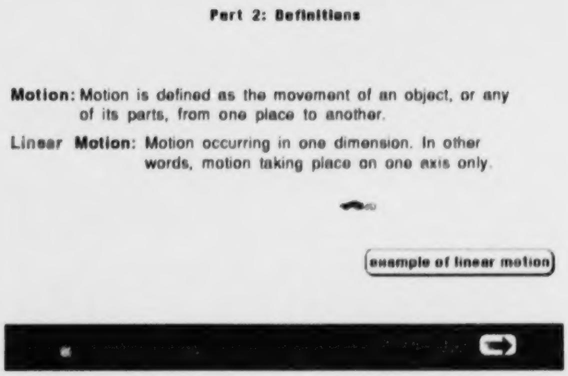
Before we start, we should have an idea of the terms we will use throughout this tutorial.



Part 2: Definitions

OBJECTIVES of Part 2:

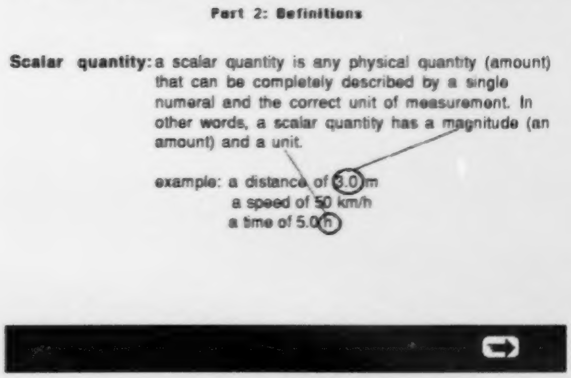
- **to define linear motion**
- **To distinguish between a vector and a scalar quantity and to give examples of each**
- **to distinguish among distance, displacement, and position**
- **to distinguish between speed and velocity**
- **to define vibration, period, and frequency**



Part 2: Definitions

Motion: Motion is defined as the movement of an object, or any of its parts, from one place to another.

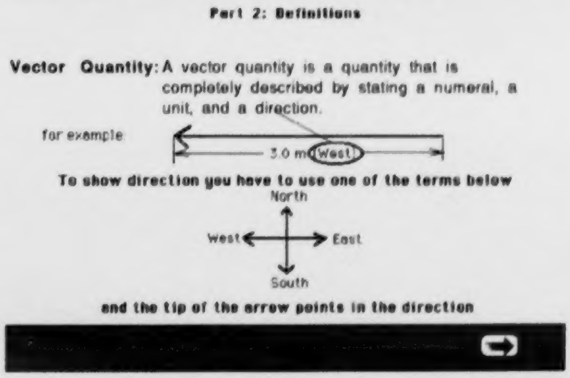
Linear **Motion:** Motion occurring in one dimension. In other words, motion taking place on one axis only.



Part 2: Definitions

Scalar quantity: a scalar quantity is any physical quantity (amount) that can be completely described by a single numeral and the correct unit of measurement. In other words, a scalar quantity has a magnitude (an amount) and a unit.

example: a distance of 3.0 m
a speed of 50 km/h
a time of 5.0 h



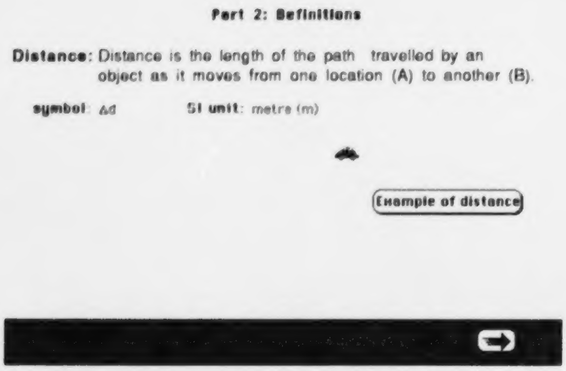
Part 2: Definitions

Vector Quantity: A vector quantity is a quantity that is completely described by stating a numeral, a unit, and a direction.

To show direction you have to use one of the terms below

and the tip of the arrow points in the direction

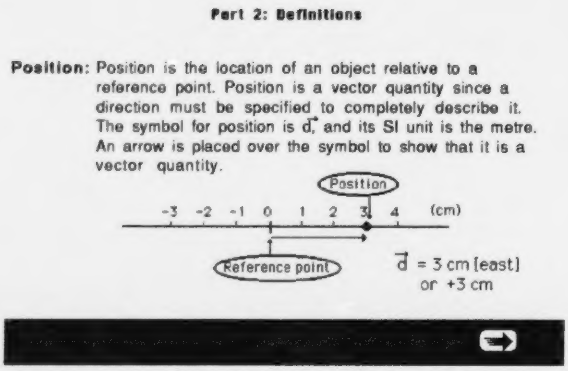
Motion



Part 2: Definitions

Distance: Distance is the length of the path travelled by an object as it moves from one location (A) to another (B).

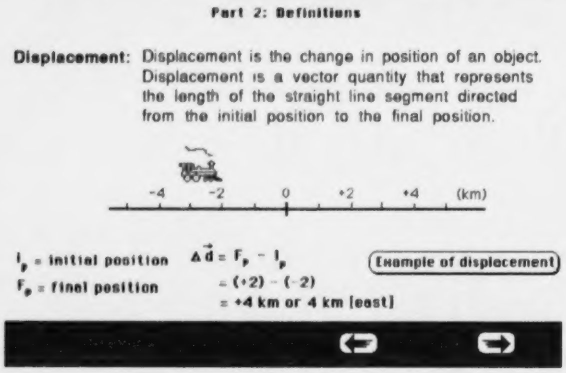
symbol: Δd **SI unit**: metre (m)



Part 2: Definitions

Position: Position is the location of an object relative to a reference point. Position is a vector quantity since a direction must be specified to completely describe it. The symbol for position is $\vec{d}$, and its SI unit is the metre. An arrow is placed over the symbol to show that it is a vector quantity.

$\vec{d}$ = 3 cm [east] or +3 cm



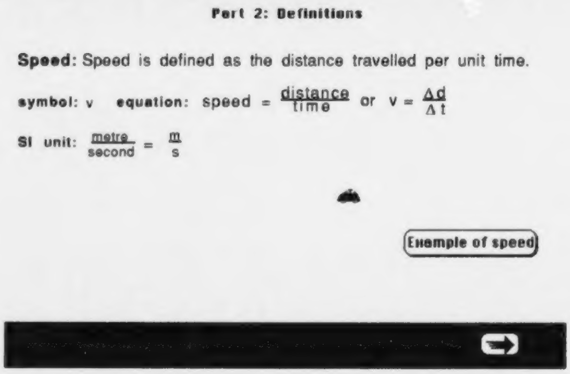
Part 2: Definitions

Displacement: Displacement is the change in position of an object. Displacement is a vector quantity that represents the length of the straight line segment directed from the initial position to the final position.

I_p = initial position

F_p = final position

$\Delta\vec{d} = F_p - I_p$
$= (+2) - (-2)$
$=$ **+4 km or 4 km [east]**

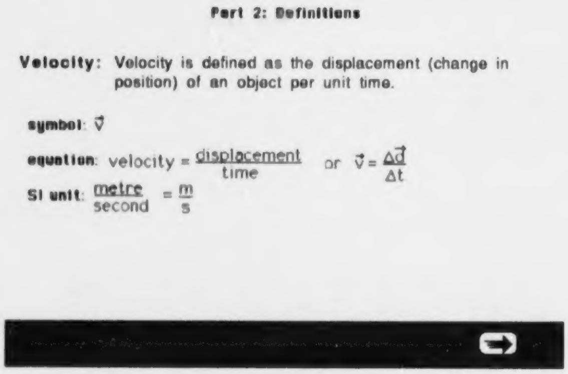


Part 2: Definitions

Speed: Speed is defined as the distance travelled per unit time.

symbol: v **equation:** speed = $\frac{\text{distance}}{\text{time}}$ or $v = \frac{\Delta d}{\Delta t}$

SI unit: $\frac{\text{metre}}{\text{second}} = \frac{m}{s}$



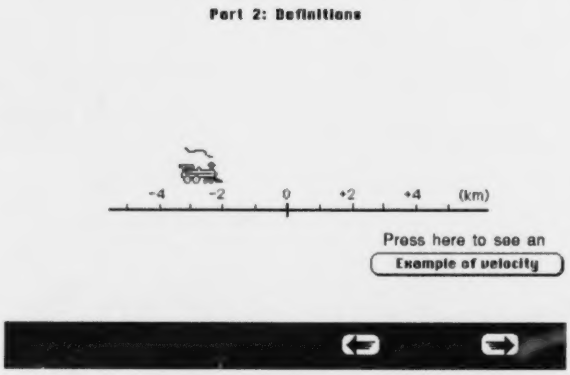
Part 2: Definitions

Velocity: Velocity is defined as the displacement (change in position) of an object per unit time.

symbol: $\vec{v}$

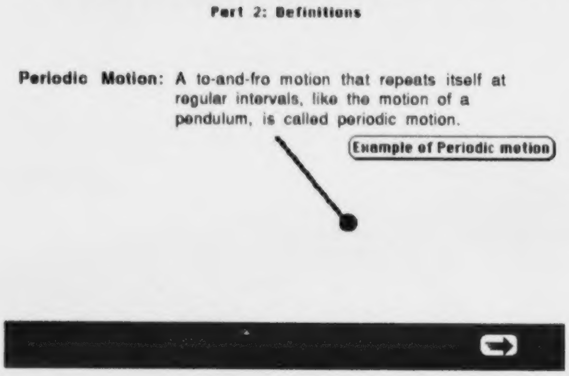
equation: velocity = $\frac{\text{displacement}}{\text{time}}$ or $\vec{v} = \frac{\Delta\vec{d}}{\Delta t}$

SI unit: $\frac{\text{metre}}{\text{second}} = \frac{m}{s}$



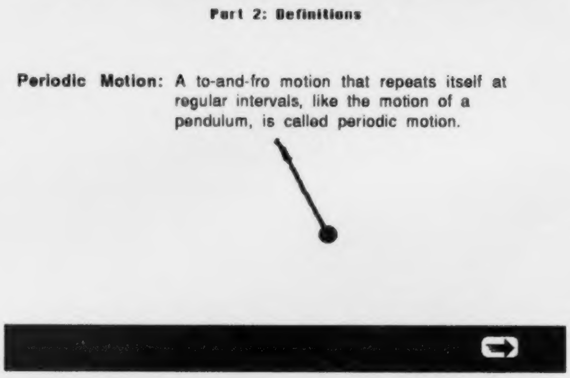
Part 2: Definitions

Press here to see an



Part 2: Definitions

Periodic Motion: A to-and-fro motion that repeats itself at regular intervals, like the motion of a pendulum, is called periodic motion.



Part 2: Definitions

Periodic Motion: A to-and-fro motion that repeats itself at regular intervals, like the motion of a pendulum, is called periodic motion.

Motion

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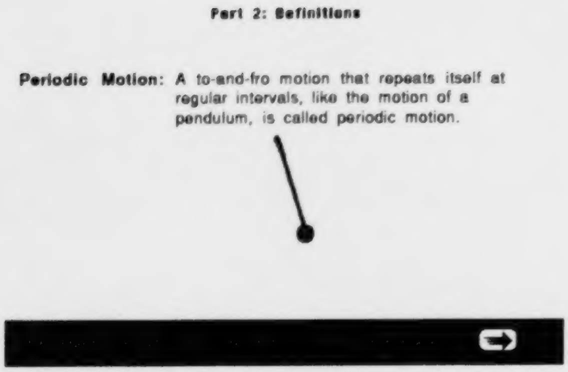
Motion



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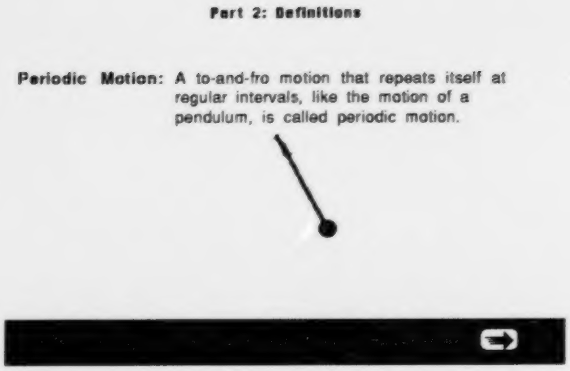
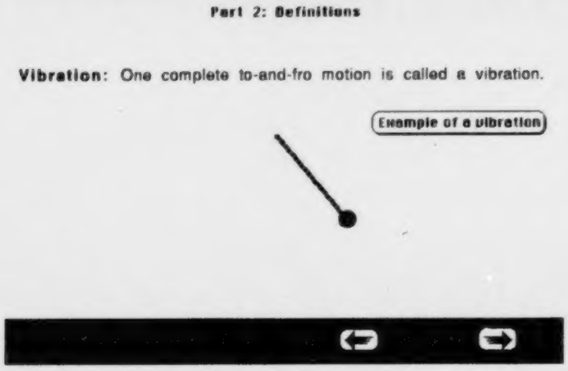


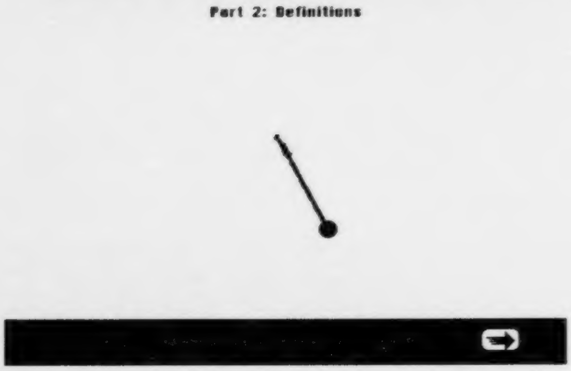
Part 2: Definitions

Periodic Motion: A to-and-fro motion that repeats itself at regular intervals, like the motion of a pendulum, is called periodic motion.



Part 2: Definitions

Vibration: One complete to-and-fro motion is called a vibration.



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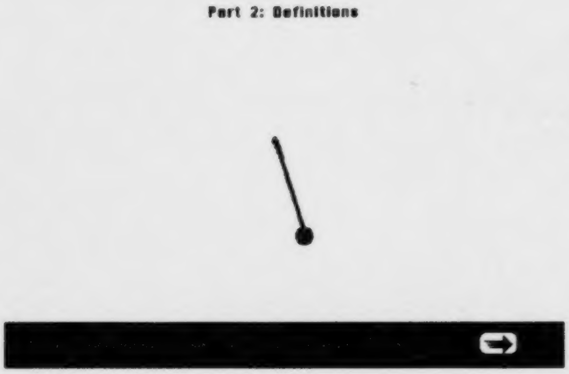

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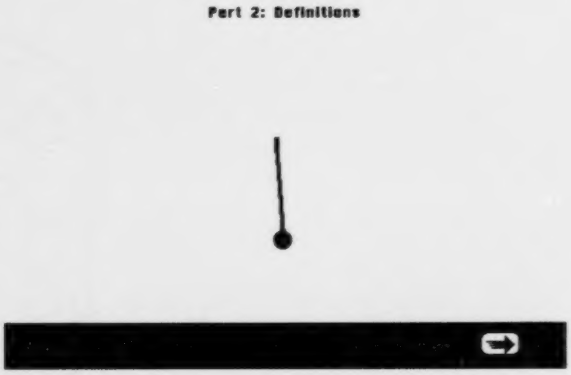

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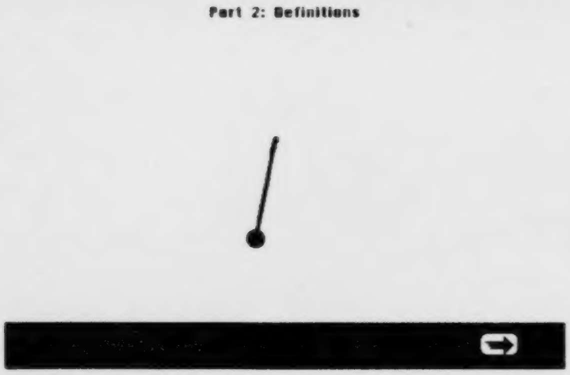

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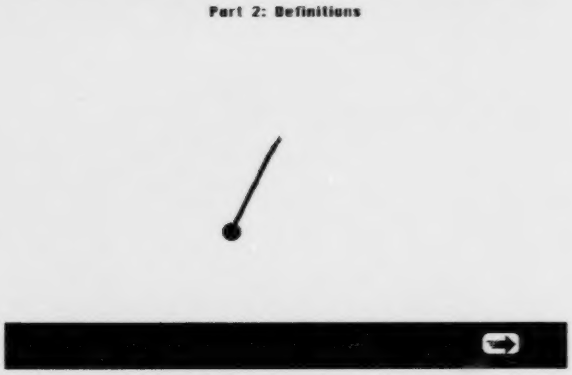
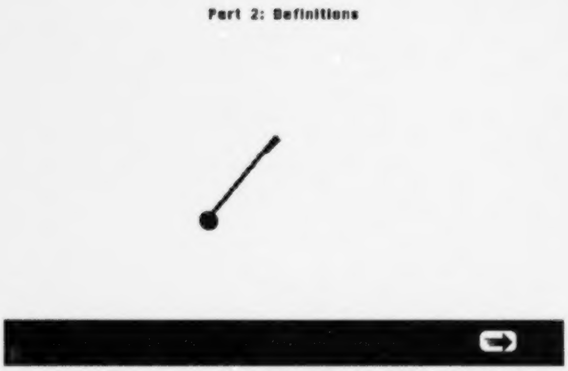
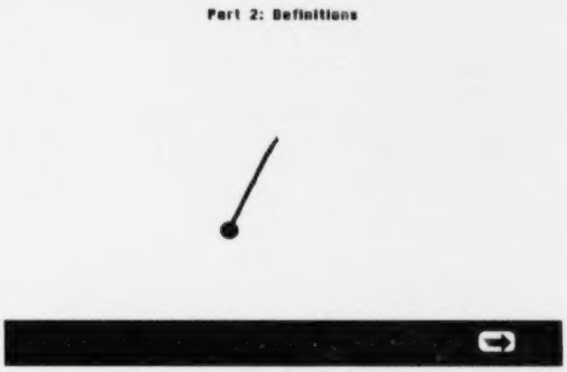


Part 2: Definitions

Motion


Part 2: Definitions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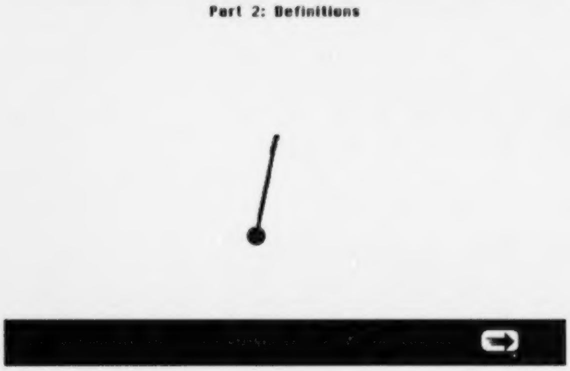
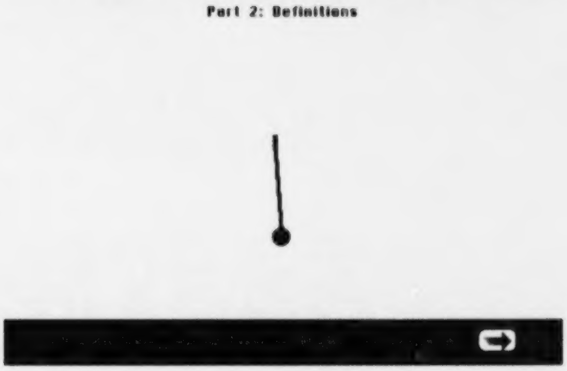
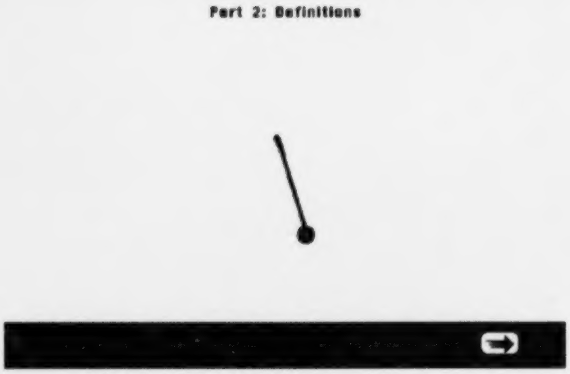
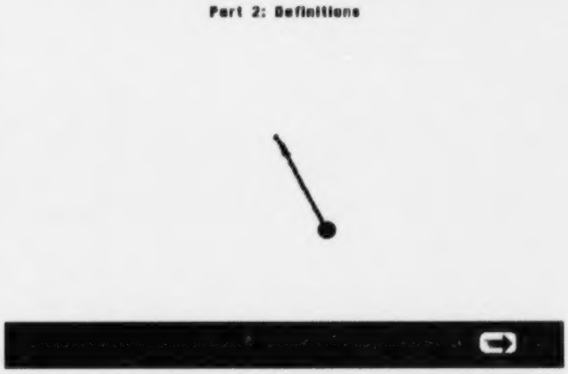
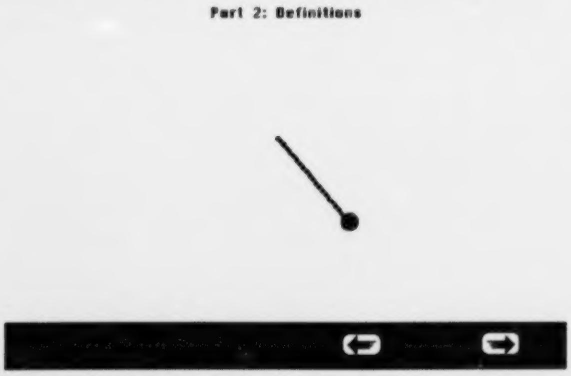
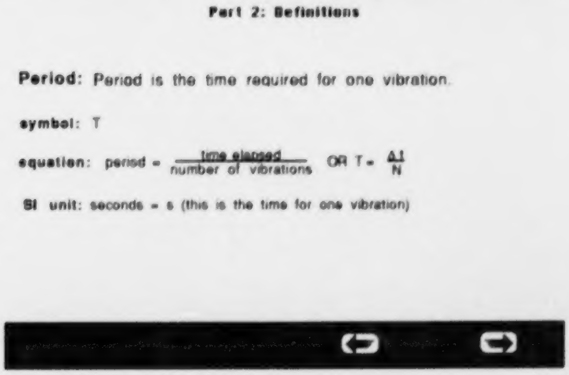

Part 2: Definitions


Part 2: Definitions


Part 2: Definitions


Part 2: Definitions


Part 2: Definitions


Part 2: Definitions

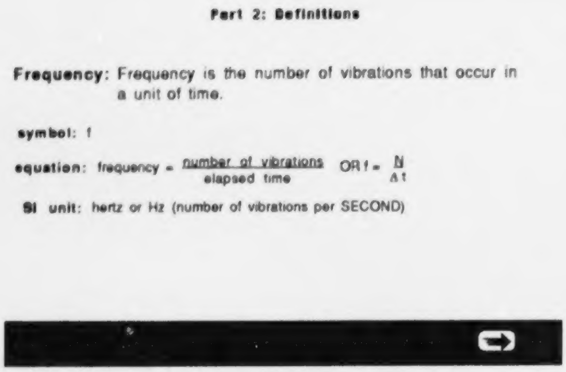
Period: Period is the time required for one vibration.

symbol: T

equation: period = $\frac{\text{time elapsed}}{\text{number of vibrations}}$ OR $T = \frac{\Delta t}{N}$

SI unit: seconds = s (this is the time for one vibration)

Motion



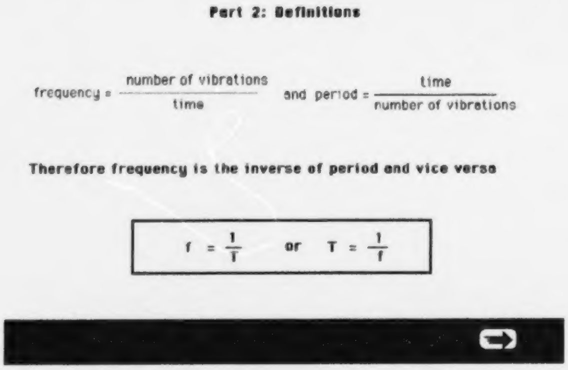
Part 2: Definitions

Frequency: Frequency is the number of vibrations that occur in a unit of time.

symbol: f

equation: $\text{frequency} = \frac{\text{number of vibrations}}{\text{elapsed time}}$ OR $f = \frac{N}{\Delta t}$

SI unit: hertz or Hz (number of vibrations per SECOND)

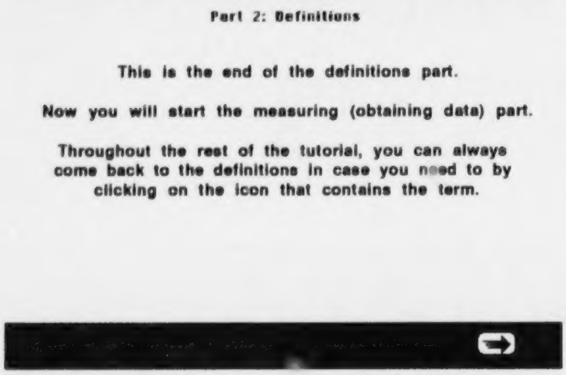


Part 2: Definitions

$\text{frequency} = \frac{\text{number of vibrations}}{\text{time}}$ and $\text{period} = \frac{\text{time}}{\text{number of vibrations}}$

Therefore frequency is the inverse of period and vice versa

$$\boxed{f = \frac{1}{T} \quad \text{or} \quad T = \frac{1}{f}}$$

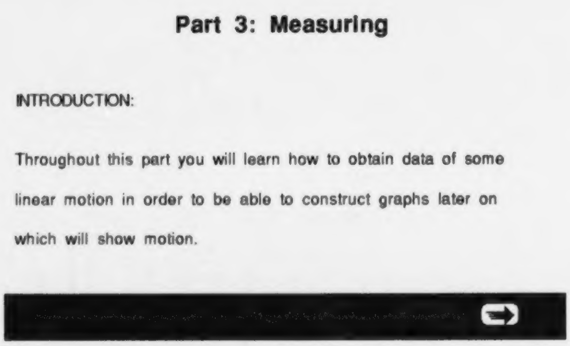


Part 2: Definitions

This is the end of the definitions part.

Now you will start the measuring (obtaining data) part.

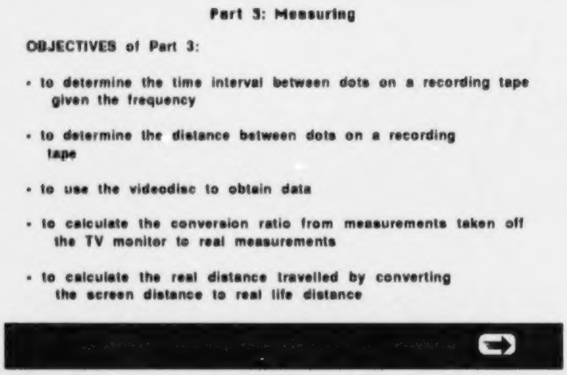
Throughout the rest of the tutorial, you can always come back to the definitions in case you need to by clicking on the icon that contains the term.



Part 3: Measuring

INTRODUCTION:

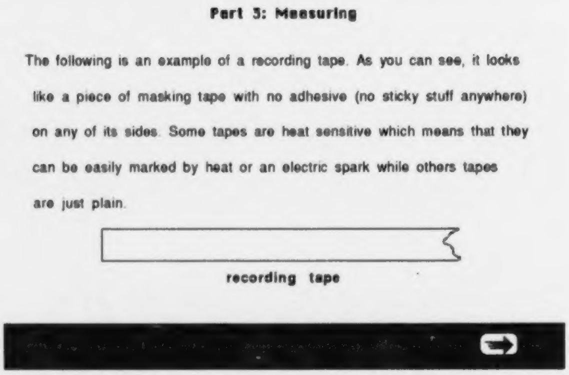
Throughout this part you will learn how to obtain data of some linear motion in order to be able to construct graphs later on which will show motion.



Part 3: Measuring

OBJECTIVES of Part 3:

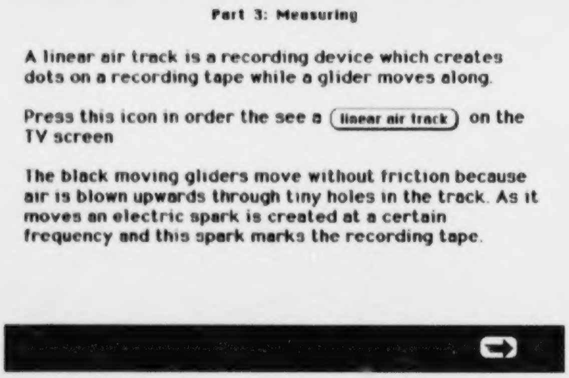
- **to determine the time interval between dots on a recording tape given the frequency**
- **to determine the distance between dots on a recording tape**
- **to use the videodisc to obtain data**
- **to calculate the conversion ratio from measurements taken off the TV monitor to real measurements**
- **to calculate the real distance travelled by converting the screen distance to real life distance**



Part 3: Measuring

The following is an example of a recording tape. As you can see, it looks like a piece of masking tape with no adhesive (no sticky stuff anywhere) on any of its sides. Some tapes are heat sensitive which means that they can be easily marked by heat or an electric spark while others tapes are just plain.

recording tape

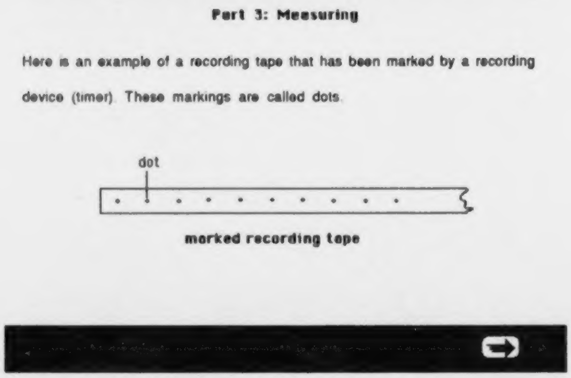


Part 3: Measuring

A linear air track is a recording device which creates dots on a recording tape while a glider moves along.

Press this icon in order the see a (linear air track) on the TV screen

The black moving gliders move without friction because air is blown upwards through tiny holes in the track. As it moves an electric spark is created at a certain frequency and this spark marks the recording tape.

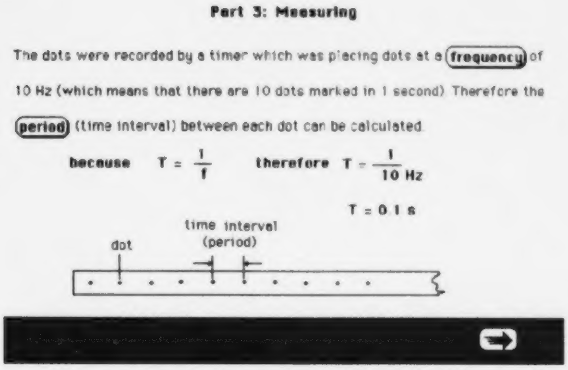


Part 3: Measuring

Here is an example of a recording tape that has been marked by a recording device (timer). These markings are called dots.

marked recording tape

Motion



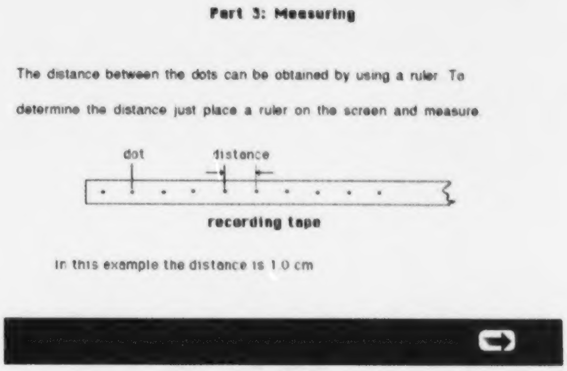
Part 3: Measuring

The dots were recorded by a timer which was placing dots at a **frequency** of 10 Hz (which means that there are 10 dots marked in 1 second). Therefore the **period** (time interval) between each dot can be calculated.

because $T = \frac{1}{f}$ **therefore** $T = \frac{1}{10\ \text{Hz}}$

$T = 0.1\ \text{s}$

dot
time interval (period)

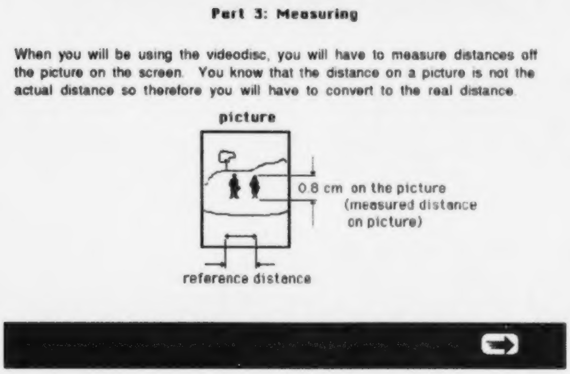


Part 3: Measuring

The distance between the dots can be obtained by using a ruler. To determine the distance just place a ruler on the screen and measure.

dot
distance
recording tape

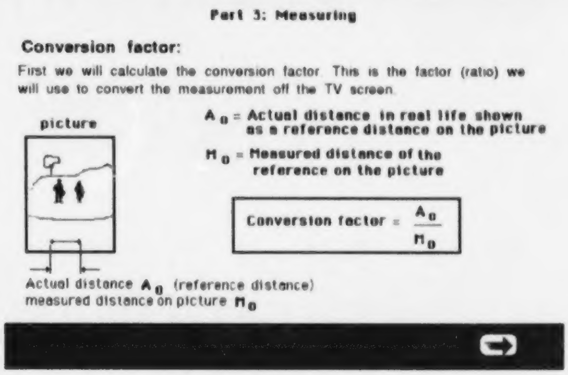
In this example the distance is 1.0 cm



Part 3: Measuring

When you will be using the videodisc, you will have to measure distances off the picture on the screen. You know that the distance on a picture is not the actual distance so therefore you will have to convert to the real distance.

picture
0.8 cm on the picture (measured distance on picture)
reference distance



Part 3: Measuring

Conversion factor:

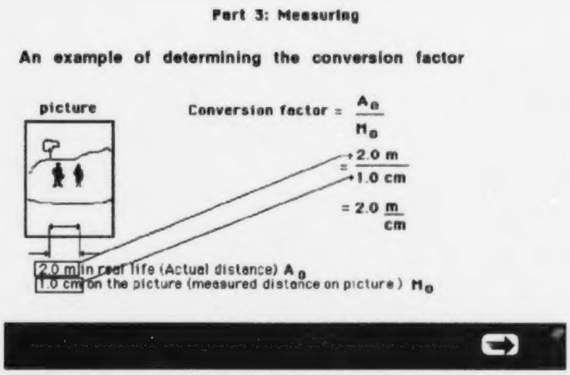
First we will calculate the conversion factor. This is the factor (ratio) we will use to convert the measurement off the TV screen.

A_0 = Actual distance in real life shown as a reference distance on the picture

M_0 = Measured distance of the reference on the picture

$$\boxed{\text{Conversion factor} = \frac{A_0}{M_0}}$$

Actual distance A_0 (reference distance)
measured distance on picture M_0

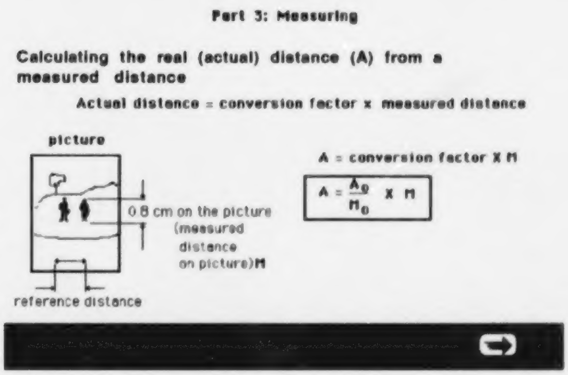


Part 3: Measuring

An example of determining the conversion factor

$$\text{Conversion factor} = \frac{A_0}{M_0} = \frac{2.0\ \text{m}}{1.0\ \text{cm}} = 2.0\ \frac{\text{m}}{\text{cm}}$$

2.0 m in real life (Actual distance) A_0
1.0 cm on the picture (measured distance on picture) M_0



Part 3: Measuring

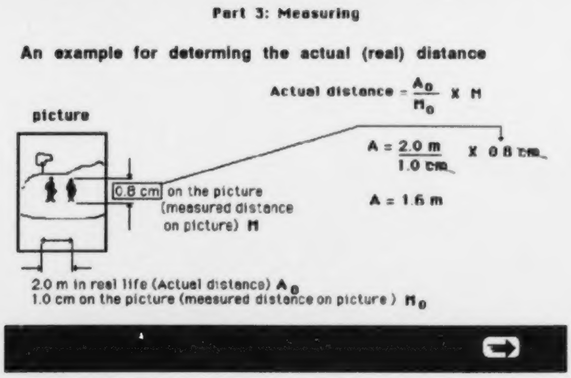
Calculating the real (actual) distance (A) from a measured distance

Actual distance = conversion factor x measured distance

picture
0.8 cm on the picture (measured distance on picture) M
reference distance

A = conversion factor X M

$$\boxed{A = \frac{A_0}{M_0} \times M}$$



Part 3: Measuring

An example for determing the actual (real) distance

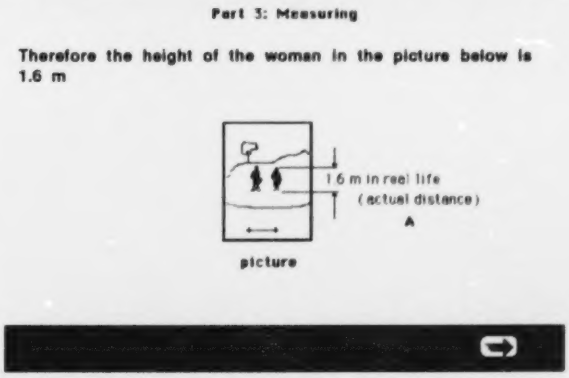
$$\text{Actual distance} = \frac{A_0}{M_0} \times M$$

picture
0.8 cm on the picture (measured distance on picture) M

$$A = \frac{2.0\ \text{m}}{1.0\ \cancel{\text{cm}}} \times 0.8\ \cancel{\text{cm}}$$

$$A = 1.6\ \text{m}$$

2.0 m in real life (Actual distance) A_0
1.0 cm on the picture (measured distance on picture) M_0

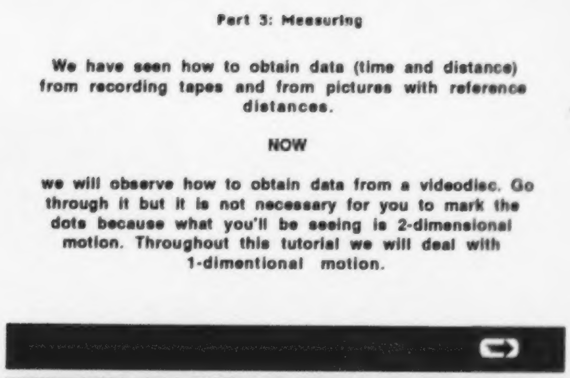


Part 3: Measuring

Therefore the height of the women in the picture below is 1.6 m

1.6 m in real life (actual distance) A
picture

Motion



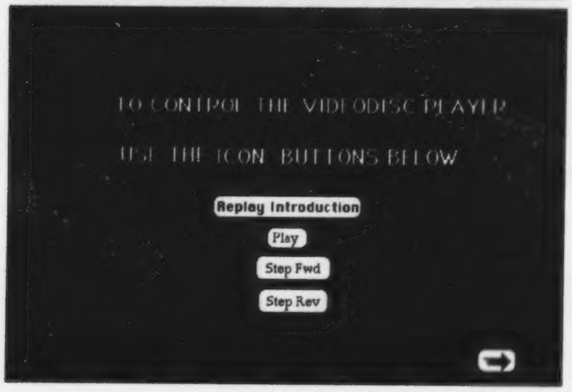
Part 3: Measuring

We have seen how to obtain data (time and distance) from recording tapes and from pictures with reference distances.

NOW

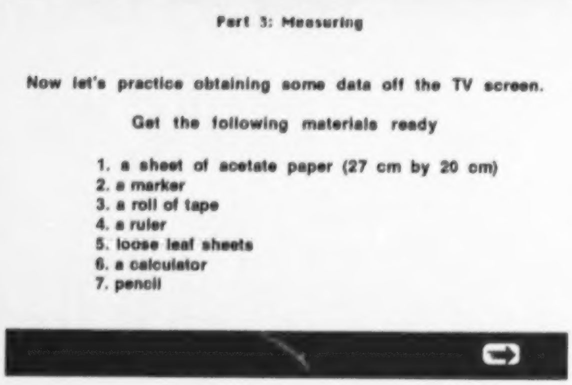
we will observe how to obtain data from a videodisc. Go through it but it is not necessary for you to mark the dots because what you'll be seeing is 2-dimensional motion. Throughout this tutorial we will deal with 1-dimentional motion.

Look at the TV Monitor



TO CONTROL THE VIDEODISC PLAYER

USE THE ICON BUTTONS BELOW

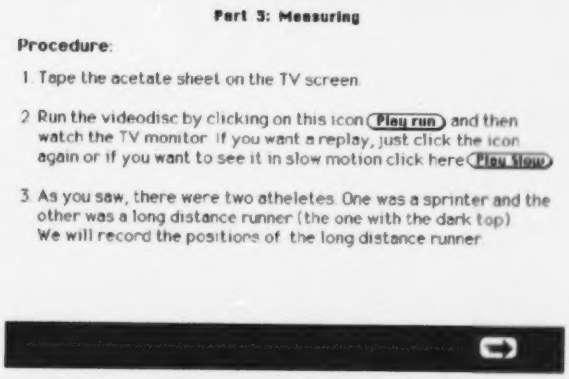


Part 3: Measuring

Now let's practice obtaining some data off the TV screen.

Get the following materials ready

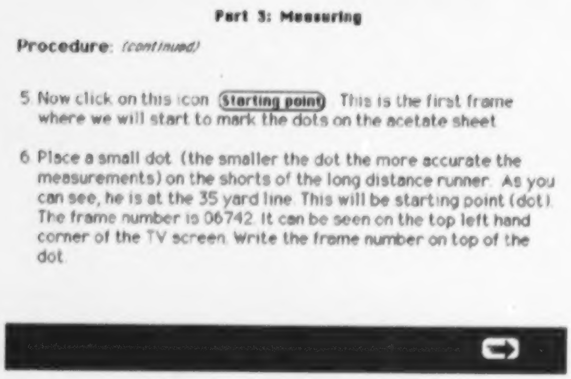
1. **a sheet of acetate paper (27 cm by 20 cm)**
2. **a marker**
3. **a roll of tape**
4. **a ruler**
5. **loose leaf sheets**
6. **a calculator**
7. **pencil**



Part 3: Measuring

Procedure:

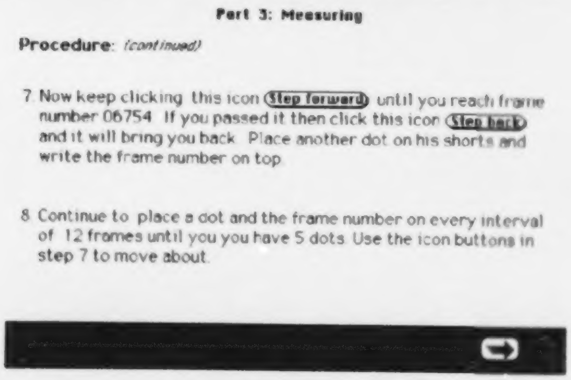
1. Tape the acetate sheet on the TV screen
2. Run the videodisc by clicking on this icon (Play run) and then watch the TV monitor If you want a replay, just click the icon again or if you want to see it in slow motion click here (Play Slow)
3. As you saw, there were two atheletes One was a sprinter and the other was a long distance runner (the one with the dark top) We will record the positions of the long distance runner



Part 3: Measuring

Procedure: *(continued)*

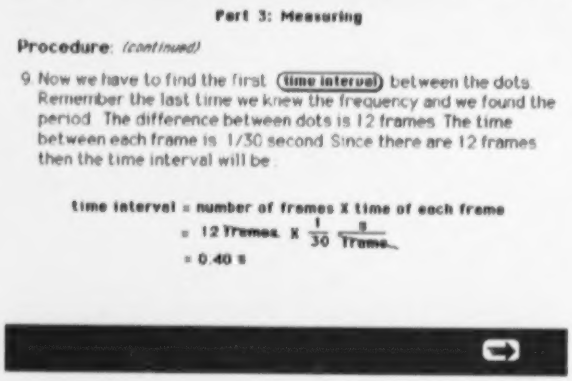
5. Now click on this icon (Starting point) This is the first frame where we will start to mark the dots on the acetate sheet
6. Place a small dot (the smaller the dot the more accurate the measurements) on the shorts of the long distance runner As you can see, he is at the 35 yard line This will be starting point (dot) The frame number is 06742 It can be seen on the top left hand corner of the TV screen Write the frame number on top of the dot



Part 3: Measuring

Procedure: *(continued)*

7. Now keep clicking this icon (Step forward) until you reach frame number 06754 If you passed it then click this icon (Step back) and it will bring you back Place another dot on his shorts and write the frame number on top
8. Continue to place a dot and the frame number on every interval of 12 frames until you you have 5 dots Use the icon buttons in step 7 to move about.



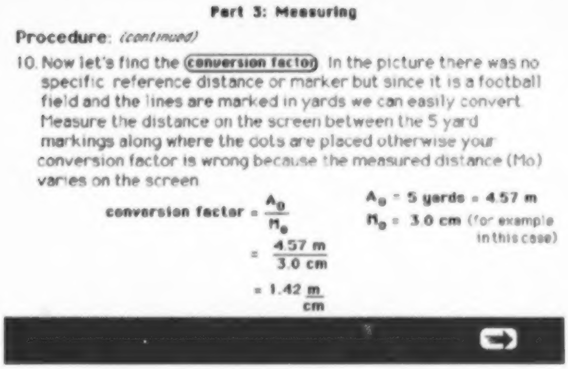
Part 3: Measuring

Procedure: *(continued)*

9. Now we have to find the first (time interval) between the dots Remember the last time we knew the frequency and we found the period The difference between dots is 12 frames The time between each frame is 1/30 second Since there are 12 frames then the time interval will be

$$\begin{aligned}\text{time interval} &= \text{number of frames} \times \text{time of each frame}\\ &= 12\ \cancel{\text{frames}} \times \frac{1}{30}\,\frac{\text{s}}{\cancel{\text{frame}}}\\ &= 0.40\ \text{s}\end{aligned}$$

Motion



Part 3: Measuring

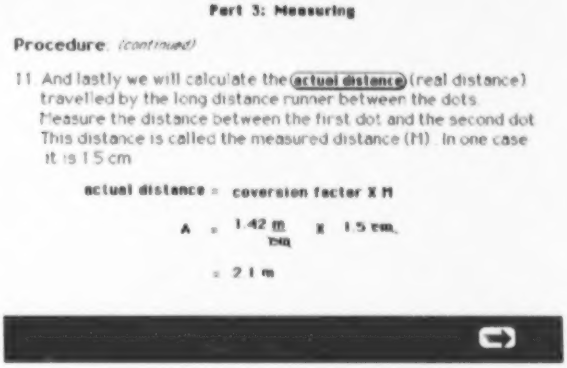
Procedure: *(continued)*

10. Now let's find the **conversion factor** In the picture there was no specific reference distance or marker but since it is a football field and the lines are marked in yards we can easily convert Measure the distance on the screen between the 5 yard markings along where the dots are placed otherwise your conversion factor is wrong because the measured distance (Mo) varies on the screen

$$\text{conversion factor} = \frac{A_0}{M_0} = \frac{4.57\ \text{m}}{3.0\ \text{cm}} = 1.42\ \frac{\text{m}}{\text{cm}}$$

A_0 = 5 yards = 4.57 m

M_0 = 3.0 cm (for example in this case)



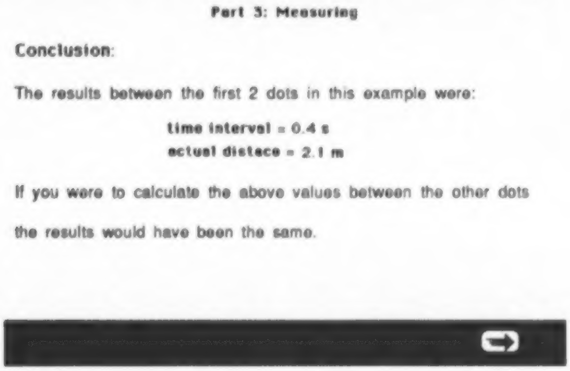
Part 3: Measuring

Procedure: *(continued)*

11. And lastly we will calculate the **actual distance** (real distance) travelled by the long distance runner between the dots Measure the distance between the first dot and the second dot This distance is called the measured distance (M). In one case it is 1.5 cm

actual distance = coversion factor X M

$$A = 1.42\ \frac{\text{m}}{\text{cm}} \times 1.5\ \text{cm} = 2.1\ \text{m}$$



Part 3: Measuring

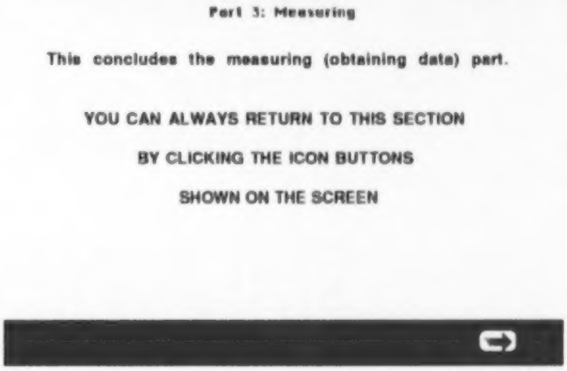
Conclusion:

The results between the first 2 dots in this example were:

time interval = 0.4 s

actual distace = 2.1 m

If you were to calculate the above values between the other dots the results would have been the same.



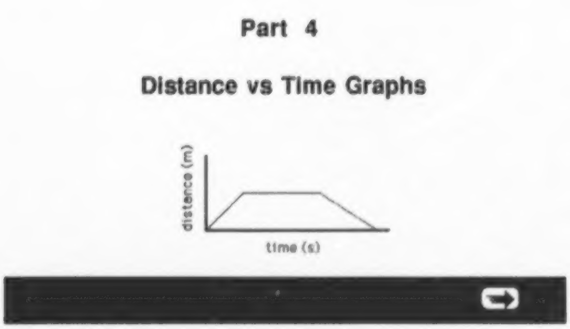
Part 3: Measuring

This concludes the measuring (obtaining data) part.

YOU CAN ALWAYS RETURN TO THIS SECTION

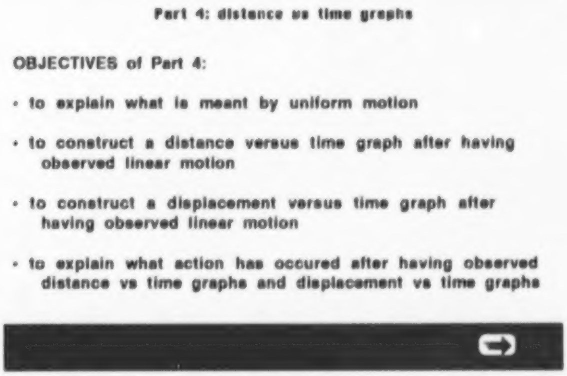
BY CLICKING THE ICON BUTTONS

SHOWN ON THE SCREEN



Part 4

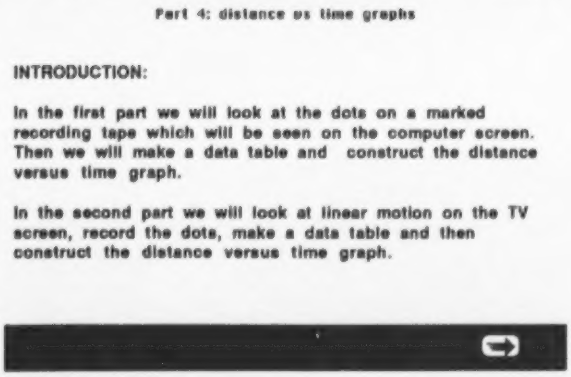
Distance vs Time Graphs



Part 4: distance vs time graphs

OBJECTIVES of Part 4:

- to explain what is meant by uniform motion
- to construct a distance versus time graph after having observed linear motion
- to construct a displacement versus time graph after having observed linear motion
- to explain what action has occured after having observed distance vs time graphs and displacement vs time graphs

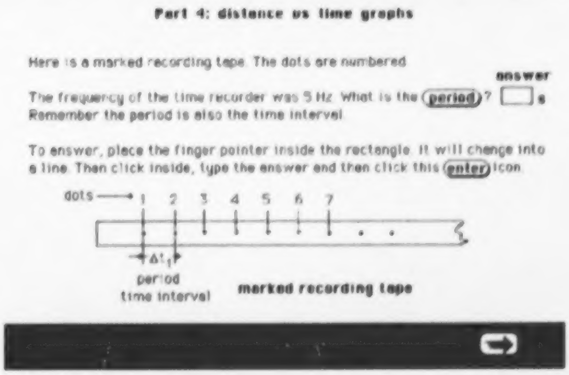


Part 4: distance vs time graphs

INTRODUCTION:

In the first part we will look at the dots on a marked recording tape which will be seen on the computer screen. Then we will make a data table and construct the distance versus time graph.

In the second part we will look at linear motion on the TV screen, record the dots, make a data table and then construct the distance versus time graph.



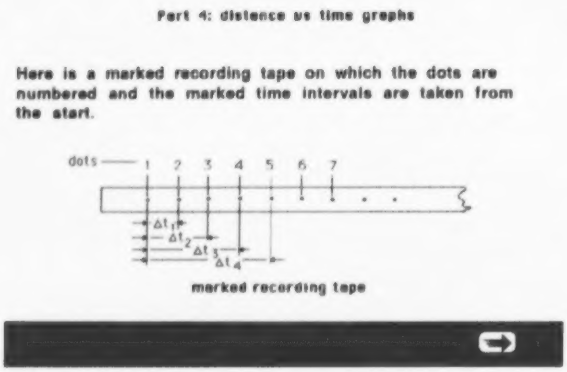
Part 4: distance vs time graphs

Here is a marked recording tape The dots are numbered

The frequency of the time recorder was 5 Hz What is the **period**? ☐ s **answer**
Remember the period is also the time interval

To answer, place the finger pointer inside the rectangle It will change into a line Then click inside, type the answer and then click this **enter** icon

Motion

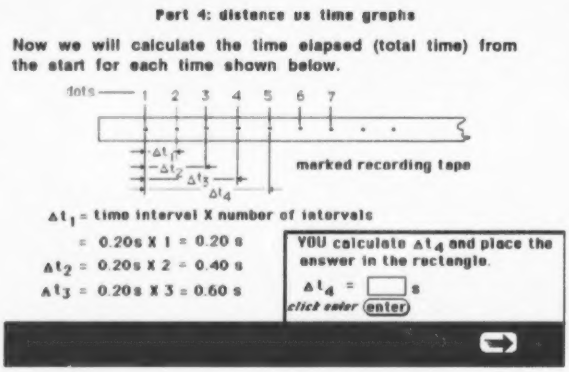


Part 4: distance vs time graphs

Here is a marked recording tape on which the dots are numbered and the marked time intervals are taken from the start.

dots
1
2
3
4
5
6
7
Δt_1
Δt_2
Δt_3
Δt_4

marked recording tape



Part 4: distance vs time graphs

Now we will calculate the time elapsed (total time) from the start for each time shown below.

dots
1
2
3
4
5
6
7
Δt_1
Δt_2
Δt_3
Δt_4

marked recording tape

Δt_1 = time interval X number of intervals

= 0.20s X 1 = 0.20 s

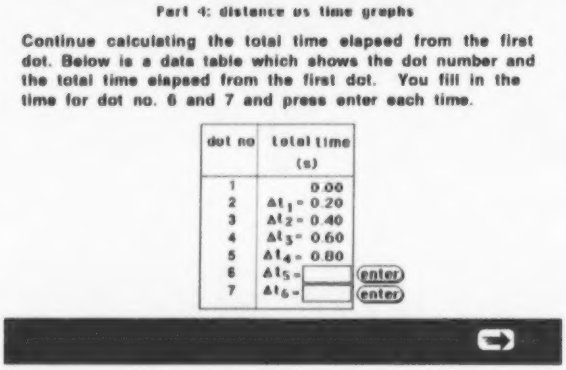
Δt_2 = 0.20s X 2 = 0.40 s

Δt_3 = 0.20s X 3 = 0.60 s

YOU calculate Δt_4 and place the answer in the rectangle.

Δt_4 = ☐ s

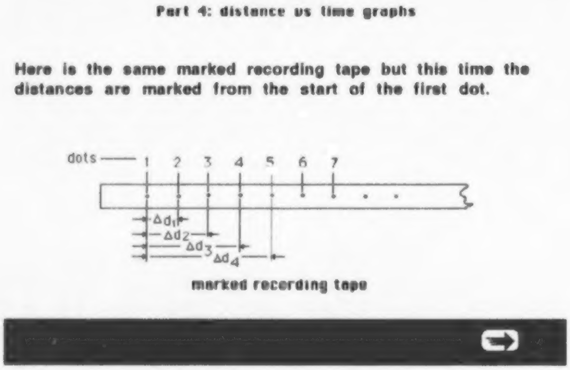
click enter (enter)



Part 4: distance vs time graphs

Continue calculating the total time elapsed from the first dot. Below is a data table which shows the dot number and the total time elapsed from the first dot. You fill in the time for dot no. 6 and 7 and press enter each time.

dot no	total time (s)
1	0.00
2	Δt_1 = 0.20
3	Δt_2 = 0.40
4	Δt_3 = 0.60
5	Δt_4 = 0.80
6	Δt_5 = ☐ (enter)
7	Δt_6 = ☐ (enter)

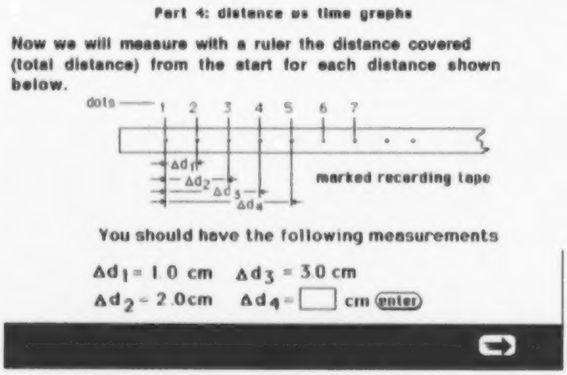


Part 4: distance vs time graphs

Here is the same marked recording tape but this time the distances are marked from the start of the first dot.

dots
1
2
3
4
5
6
7
Δd_1
Δd_2
Δd_3
Δd_4

marked recording tape



Part 4: distance vs time graphs

Now we will measure with a ruler the distance covered (total distance) from the start for each distance shown below.

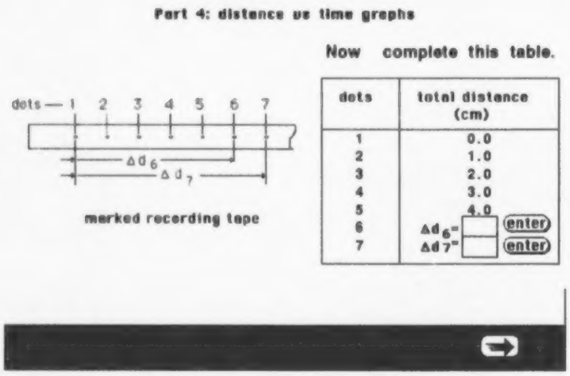
dots
1
2
3
4
5
6
7
Δd_1
Δd_2
Δd_3
Δd_4

marked recording tape

You should have the following measurements

Δd_1 = 1.0 cm Δd_3 = 3.0 cm

Δd_2 = 2.0cm Δd_4 = ☐ cm (enter)



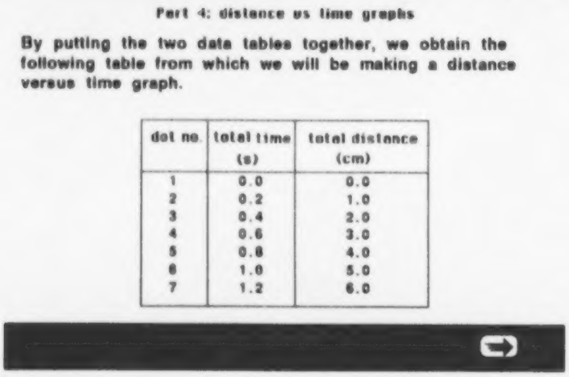
Part 4: distance vs time graphs

Now complete this table.

dots
1
2
3
4
5
6
7
Δd_6
Δd_7

marked recording tape

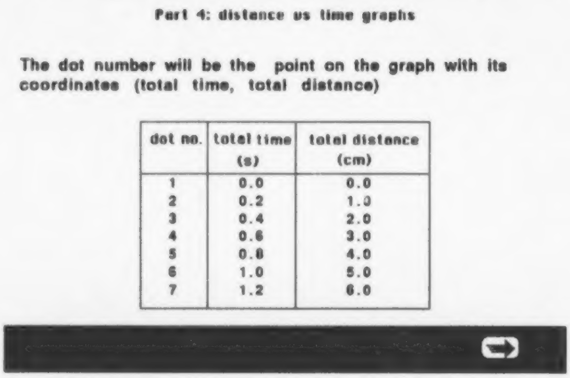
dots	total distance (cm)
1	0.0
2	1.0
3	2.0
4	3.0
5	4.0
6	Δd_6 = ☐ (enter)
7	Δd_7 = ☐ (enter)



Part 4: distance vs time graphs

By putting the two data tables together, we obtain the following table from which we will be making a distance versus time graph.

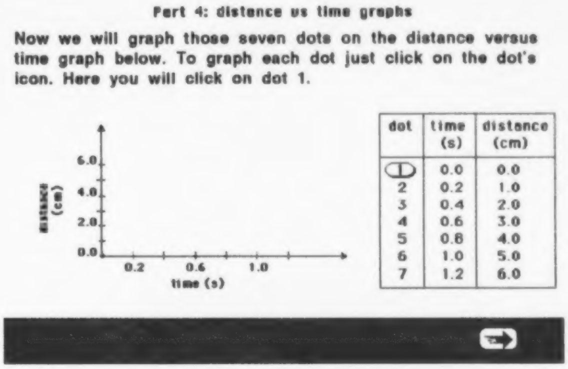
dot no.	total time (s)	total distance (cm)
1	0.0	0.0
2	0.2	1.0
3	0.4	2.0
4	0.6	3.0
5	0.8	4.0
6	1.0	5.0
7	1.2	6.0



Part 4: distance vs time graphs

The dot number will be the point on the graph with its coordinates (total time, total distance)

dot no.	total time (s)	total distance (cm)
1	0.0	0.0
2	0.2	1.0
3	0.4	2.0
4	0.6	3.0
5	0.8	4.0
6	1.0	5.0
7	1.2	6.0

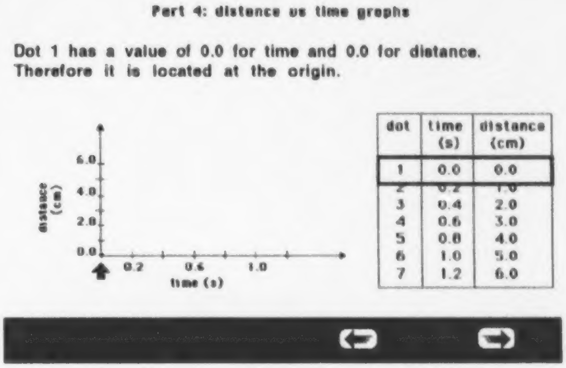


Part 4: distance vs time graphs

Now we will graph those seven dots on the distance versus time graph below. To graph each dot just click on the dot's icon. Here you will click on dot 1.

dot	time (s)	distance (cm)
1	0.0	0.0
2	0.2	1.0
3	0.4	2.0
4	0.6	3.0
5	0.8	4.0
6	1.0	5.0
7	1.2	6.0

distance (cm)
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)

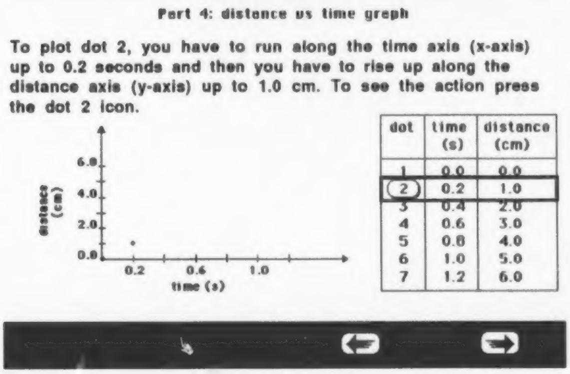


Part 4: distance vs time graphs

Dot 1 has a value of 0.0 for time and 0.0 for distance. Therefore it is located at the origin.

dot	time (s)	distance (cm)
1	0.0	0.0
2	0.2	1.0
3	0.4	2.0
4	0.6	3.0
5	0.8	4.0
6	1.0	5.0
7	1.2	6.0

distance (cm)
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)

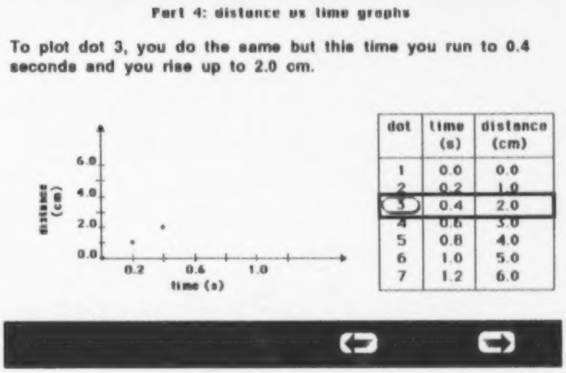


Part 4: distance vs time graph

To plot dot 2, you have to run along the time axis (x-axis) up to 0.2 seconds and then you have to rise up along the distance axis (y-axis) up to 1.0 cm. To see the action press the dot 2 icon.

dot	time (s)	distance (cm)
1	0.0	0.0
2	0.2	1.0
3	0.4	2.0
4	0.6	3.0
5	0.8	4.0
6	1.0	5.0
7	1.2	6.0

distance (cm)
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)

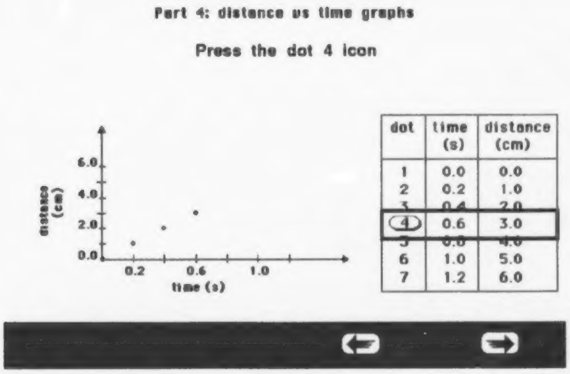


Part 4: distance vs time graphs

To plot dot 3, you do the same but this time you run to 0.4 seconds and you rise up to 2.0 cm.

dot	time (s)	distance (cm)
1	0.0	0.0
2	0.2	1.0
3	0.4	2.0
4	0.6	3.0
5	0.8	4.0
6	1.0	5.0
7	1.2	6.0

distance (cm)
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)

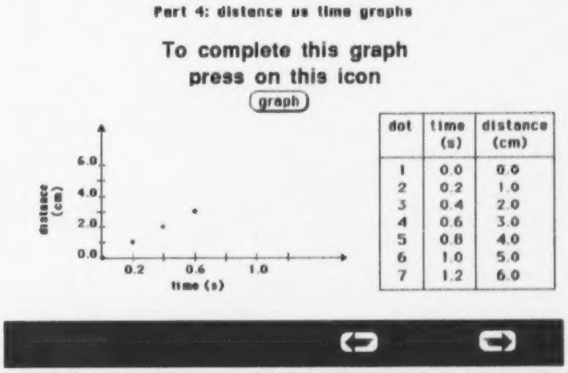


Part 4: distance vs time graphs

Press the dot 4 icon

dot	time (s)	distance (cm)
1	0.0	0.0
2	0.2	1.0
3	0.4	2.0
4	0.6	3.0
5	0.8	4.0
6	1.0	5.0
7	1.2	6.0

distance (cm)
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)

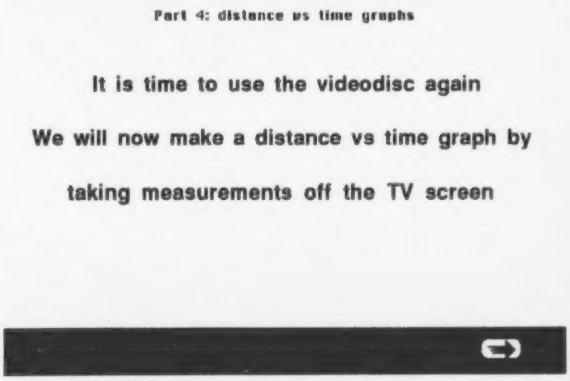


Part 4: distance vs time graphs

To complete this graph
press on this icon
graph

dot	time (s)	distance (cm)
1	0.0	0.0
2	0.2	1.0
3	0.4	2.0
4	0.6	3.0
5	0.8	4.0
6	1.0	5.0
7	1.2	6.0

distance (cm)
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)



Part 4: distance vs time graphs

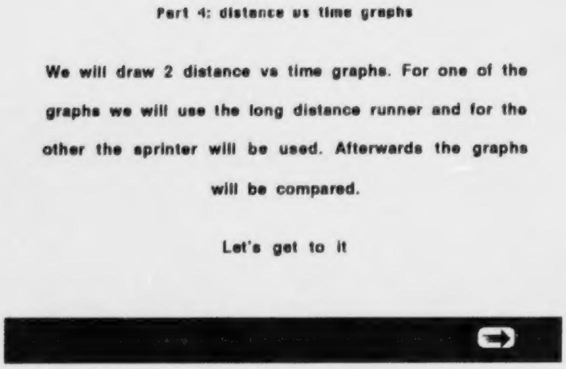
It is time to use the videodisc again

We will now make a distance vs time graph by

taking measurements off the TV screen

Look at the TV Monitor

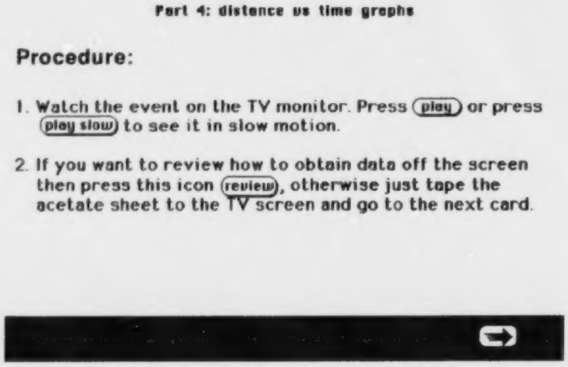
Motion



Part 4: distance vs time graphs

We will draw 2 distance vs time graphs. For one of the graphs we will use the long distance runner and for the other the sprinter will be used. Afterwards the graphs will be compared.

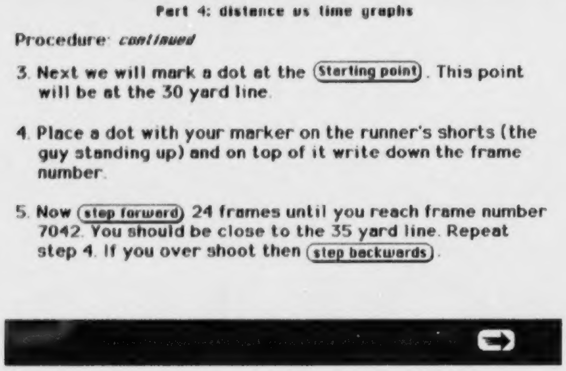
Let's get to it



Part 4: distance vs time graphs

Procedure:

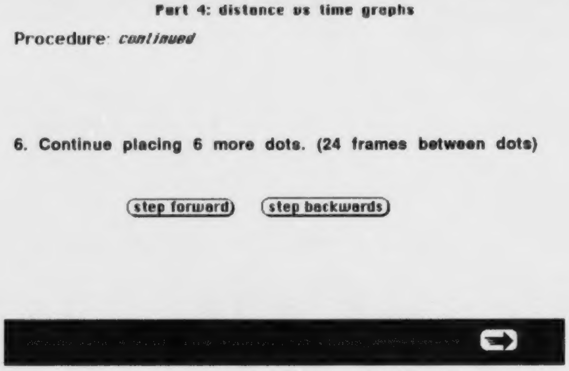
1. Watch the event on the TV monitor. Press play or press play slow to see it in slow motion.
2. If you want to review how to obtain data off the screen then press this icon review, otherwise just tape the acetate sheet to the TV screen and go to the next card.



Part 4: distance vs time graphs

Procedure: *continued*

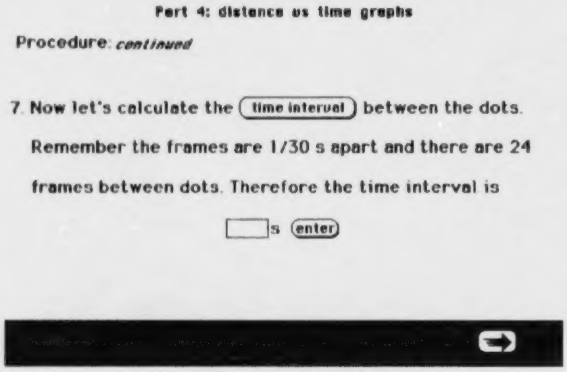
3. Next we will mark a dot at the Starting point. This point will be at the 30 yard line.
4. Place a dot with your marker on the runner's shorts (the guy standing up) and on top of it write down the frame number.
5. Now step forward 24 frames until you reach frame number 7042. You should be close to the 35 yard line. Repeat step 4. If you over shoot then step backwards.



Part 4: distance vs time graphs

Procedure: *continued*

6. Continue placing 6 more dots. (24 frames between dots)

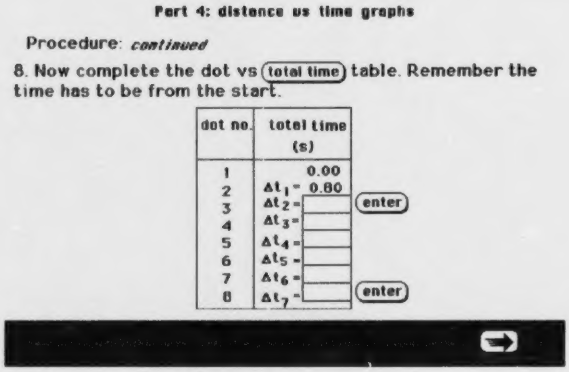


Part 4: distance vs time graphs

Procedure: *continued*

7. Now let's calculate the time interval between the dots. Remember the frames are 1/30 s apart and there are 24 frames between dots. Therefore the time interval is

☐ s enter

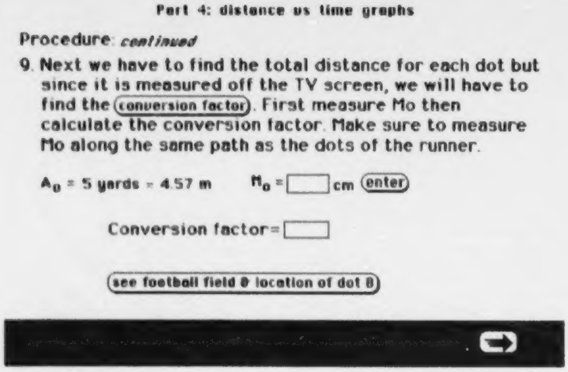


Part 4: distance vs time graphs

Procedure: *continued*

8. Now complete the dot vs total time table. Remember the time has to be from the start.

dot no.	total time (s)
1	0.00
2	Δt_1 = 0.80
3	Δt_2 = ☐
4	Δt_3 = ☐
5	Δt_4 = ☐
6	Δt_5 = ☐
7	Δt_6 = ☐
8	Δt_7 = ☐



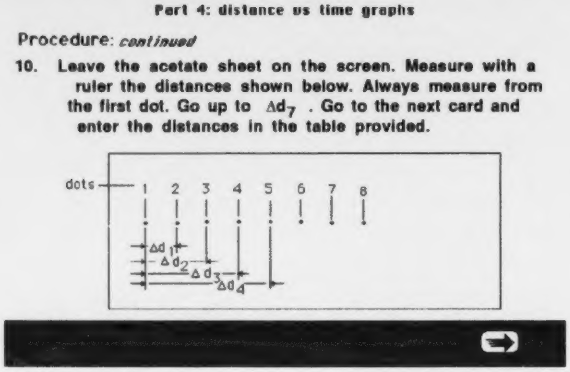
Part 4: distance vs time graphs

Procedure: *continued*

9. Next we have to find the total distance for each dot but since it is measured off the TV screen, we will have to find the conversion factor. First measure Mo then calculate the conversion factor. Make sure to measure Mo along the same path as the dots of the runner.

A_0 = 5 yards = 4.57 m M_0 = ☐ cm enter

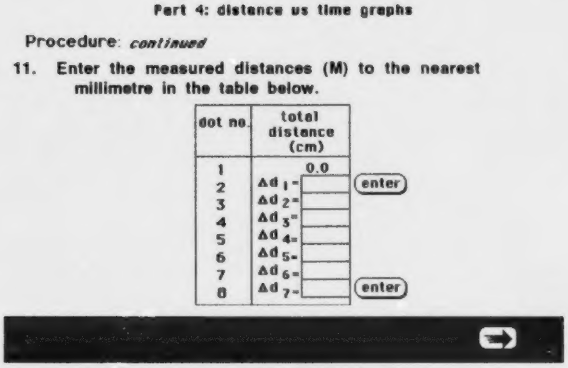
Conversion factor= ☐



Part 4: distance vs time graphs

Procedure: *continued*

10. Leave the acetate sheet on the screen. Measure with a ruler the distances shown below. Always measure from the first dot. Go up to Δd_7 . Go to the next card and enter the distances in the table provided.

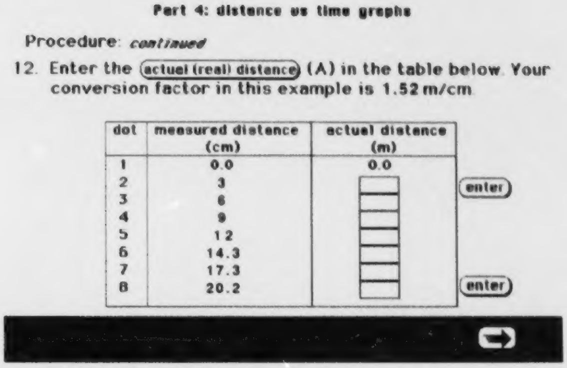


Part 4: distance vs time graphs

Procedure: *continued*

11. Enter the measured distances (M) to the nearest millimetre in the table below.

dot no.	total distance (cm)
1	0.0
2	Δd_1 = ☐
3	Δd_2 = ☐
4	Δd_3 = ☐
5	Δd_4 = ☐
6	Δd_5 = ☐
7	Δd_6 = ☐
8	Δd_7 = ☐

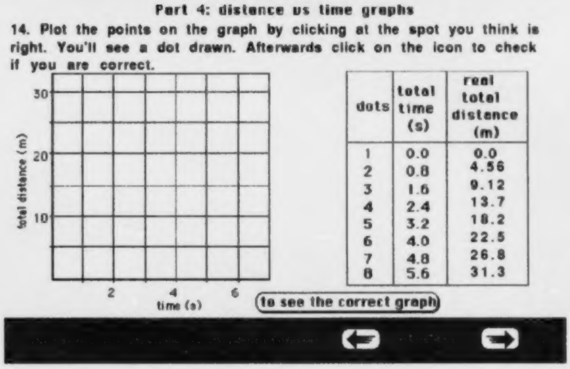


Part 4: distance vs time graphs

Procedure: *continued*

12. Enter the (actual (real) distance) (A) in the table below. Your conversion factor in this example is 1.52 m/cm

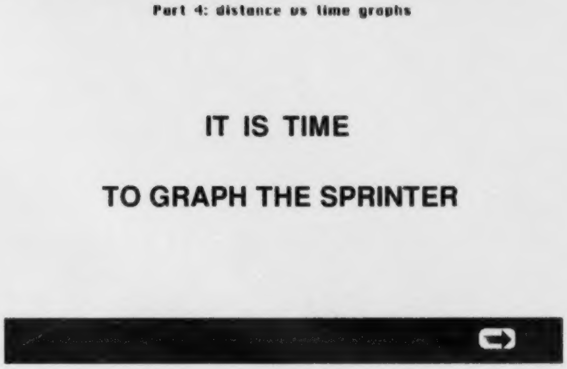
dot	measured distance (cm)	actual distance (m)
1	0.0	0.0
2	3	☐
3	6	☐
4	9	☐
5	12	☐
6	14.3	☐
7	17.3	☐
8	20.2	☐



Part 4: distance vs time graphs

14. Plot the points on the graph by clicking at the spot you think is right. You'll see a dot drawn. Afterwards click on the icon to check if you are correct.

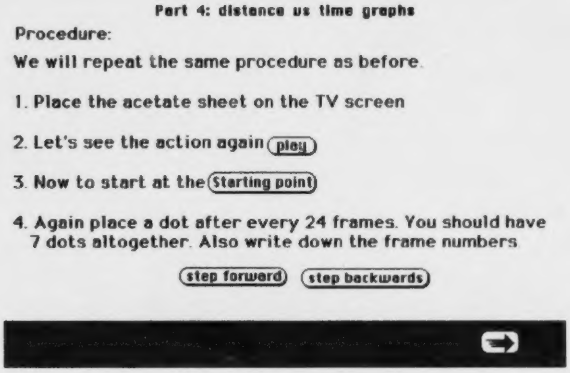
dots	total time (s)	real total distance (m)
1	0.0	0.0
2	0.8	4.56
3	1.6	9.12
4	2.4	13.7
5	3.2	18.2
6	4.0	22.5
7	4.8	26.8
8	5.6	31.3



Part 4: distance vs time graphs

IT IS TIME

TO GRAPH THE SPRINTER

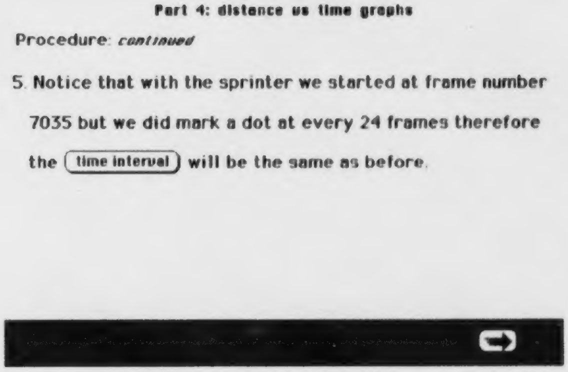


Part 4: distance vs time graphs

Procedure:

We will repeat the same procedure as before.

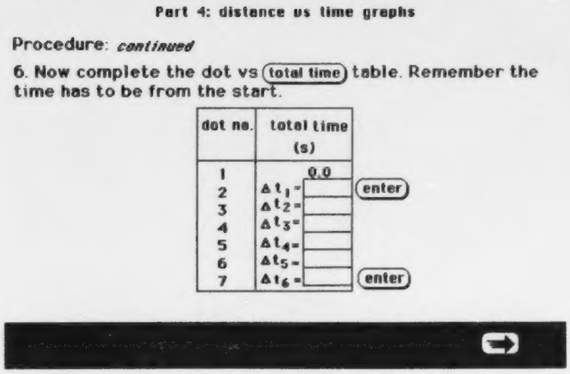
1. Place the acetate sheet on the TV screen
2. Let's see the action again (play)
3. Now to start at the (Starting point)
4. Again place a dot after every 24 frames. You should have 7 dots altogether. Also write down the frame numbers



Part 4: distance vs time graphs

Procedure: *continued*

5. Notice that with the sprinter we started at frame number 7035 but we did mark a dot at every 24 frames therefore the (time interval) will be the same as before.

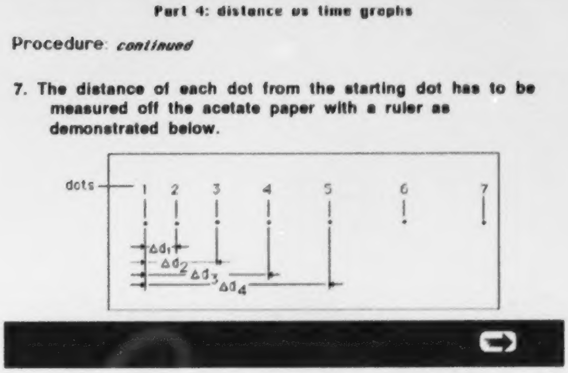


Part 4: distance vs time graphs

Procedure: *continued*

6. Now complete the dot vs (total time) table. Remember the time has to be from the start.

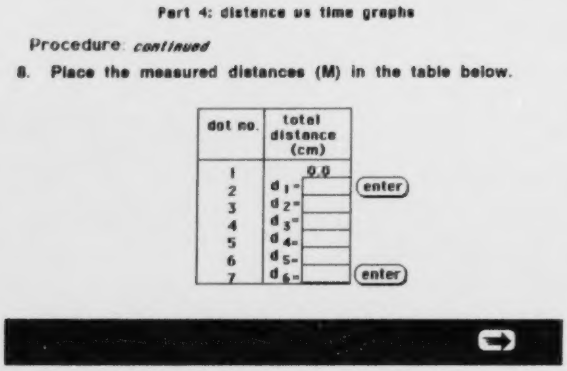
dot no.	total time (s)
1	0.0
2	Δt_1 = ☐
3	Δt_2 = ☐
4	Δt_3 = ☐
5	Δt_4 = ☐
6	Δt_5 = ☐
7	Δt_6 = ☐



Part 4: distance vs time graphs

Procedure: *continued*

7. The distance of each dot from the starting dot has to be measured off the acetate paper with a ruler as demonstrated below.



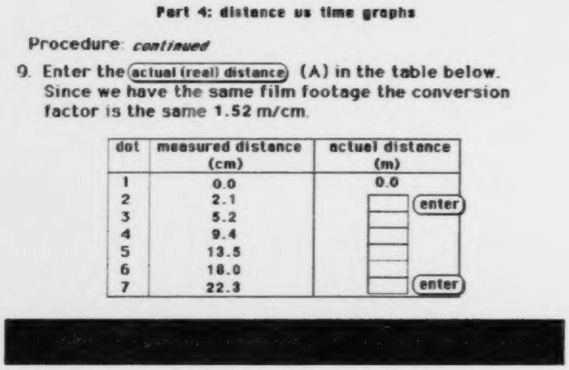
Part 4: distance vs time graphs

Procedure: *continued*

8. Place the measured distances (M) in the table below.

dot no.	total distance (cm)
1	0.0
2	d_1 = ☐
3	d_2 = ☐
4	d_3 = ☐
5	d_4 = ☐
6	d_5 = ☐
7	d_6 = ☐

enter
enter



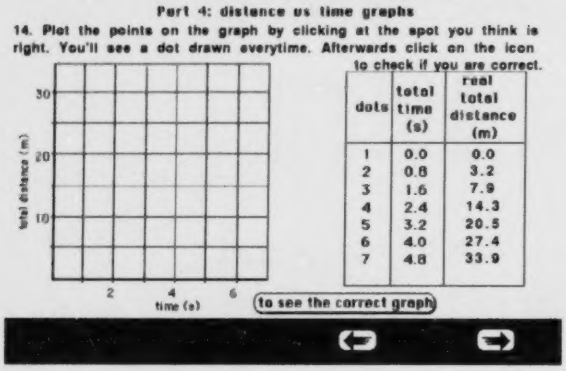
Part 4: distance vs time graphs

Procedure: *continued*

9. Enter the actual (real) distance (A) in the table below. Since we have the same film footage the conversion factor is the same 1.52 m/cm.

dot	measured distance (cm)	actual distance (m)
1	0.0	0.0
2	2.1	☐
3	5.2	☐
4	9.4	☐
5	13.5	☐
6	18.0	☐
7	22.3	☐

actual (real) distance
enter
enter

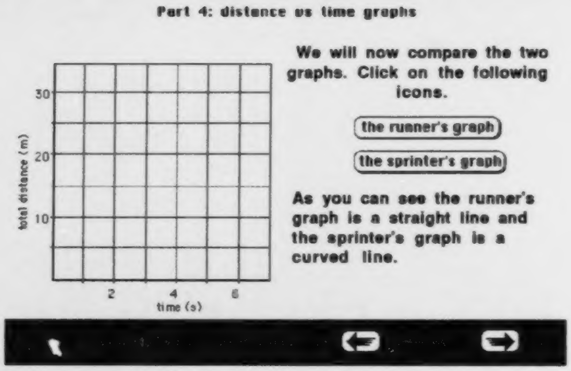


Part 4: distance vs time graphs

14. Plot the points on the graph by clicking at the spot you think is right. You'll see a dot drawn everytime. Afterwards click on the icon to check if you are correct.

dots	total time (s)	real total distance (m)
1	0.0	0.0
2	0.8	3.2
3	1.6	7.9
4	2.4	14.3
5	3.2	20.5
6	4.0	27.4
7	4.8	33.9

30
20
10
total distance (m)
2
4
6
time (s)
to see the correct graph

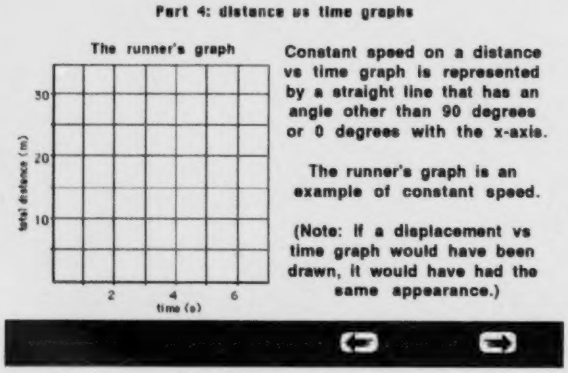


Part 4: distance vs time graphs

We will now compare the two graphs. Click on the following icons.

As you can see the runner's graph is a straight line and the sprinter's graph is a curved line.

the runner's graph
the sprinter's graph
30
20
10
total distance (m)
2
4
6
time (s)



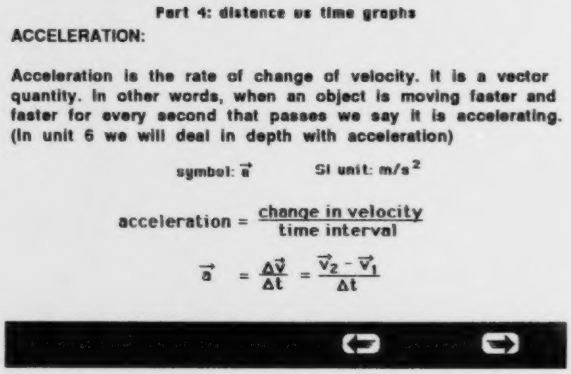
Part 4: distance vs time graphs

Constant speed on a distance vs time graph is represented by a straight line that has an angle other than 90 degrees or 0 degrees with the x-axis.

The runner's graph is an example of constant speed.

(Note: If a displacement vs time graph would have been drawn, it would have had the same appearance.)

The runner's graph
30
20
10
total distance (m)
2
4
6
time (s)



Part 4: distance vs time graphs

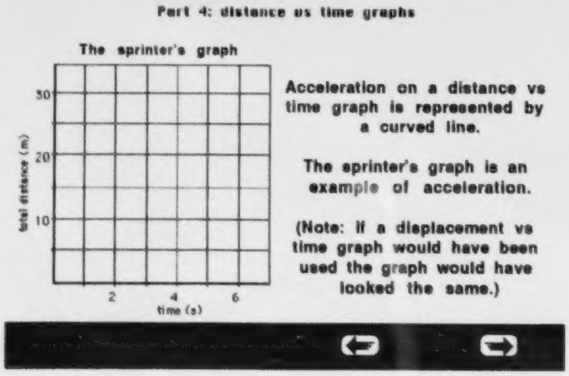
ACCELERATION:

Acceleration is the rate of change of velocity. It is a vector quantity. In other words, when an object is moving faster and faster for every second that passes we say it is accelerating. (In unit 6 we will deal in depth with acceleration)

symbol: $\vec{a}$ SI unit: m/s^2

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time interval}}$$

$$\vec{a} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$$



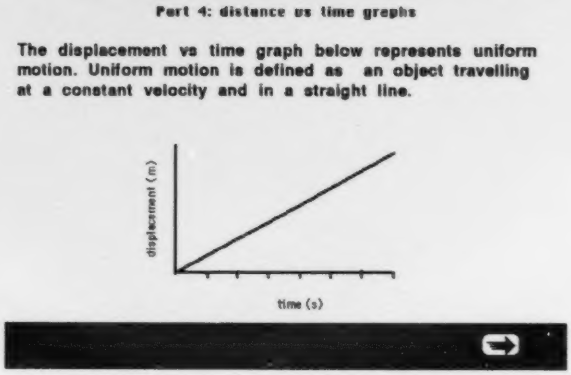
Part 4: distance vs time graphs

Acceleration on a distance vs time graph is represented by a curved line.

The sprinter's graph is an example of acceleration.

(Note: If a displacement vs time graph would have been used the graph would have looked the same.)

The sprinter's graph
30
20
10
total distance (m)
2
4
6
time (s)

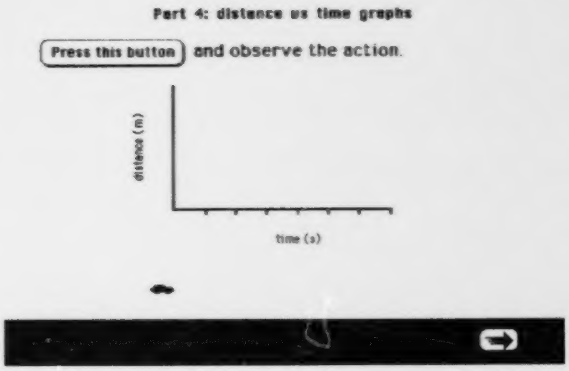


Part 4: distance vs time graphs

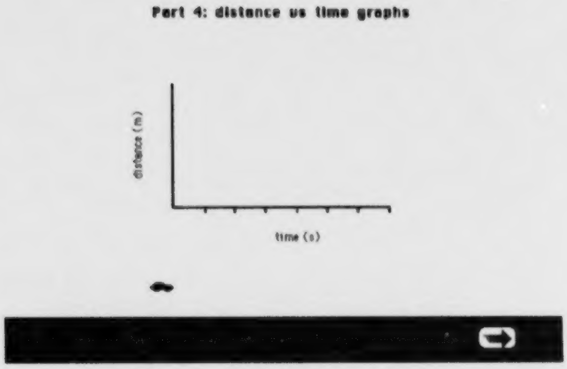
The displacement vs time graph below represents uniform motion. Uniform motion is defined as an object travelling at a constant velocity and in a straight line.

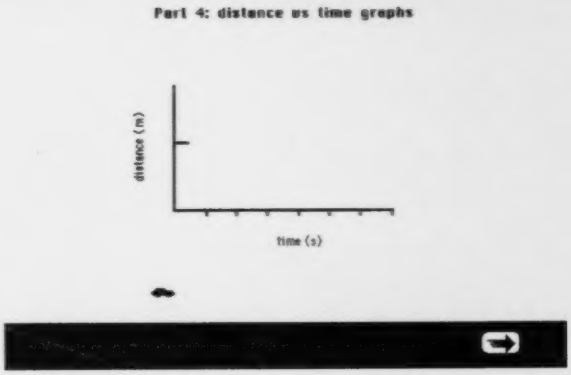
displacement (m)
time (s)

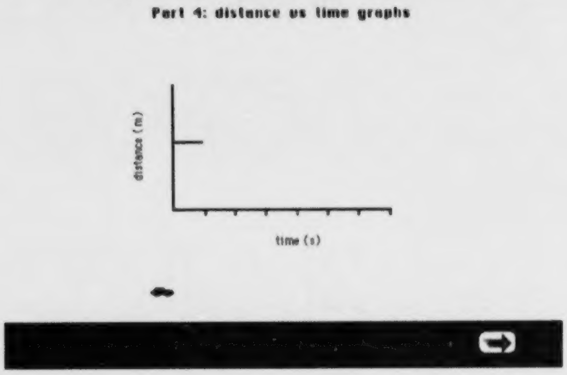
Motion

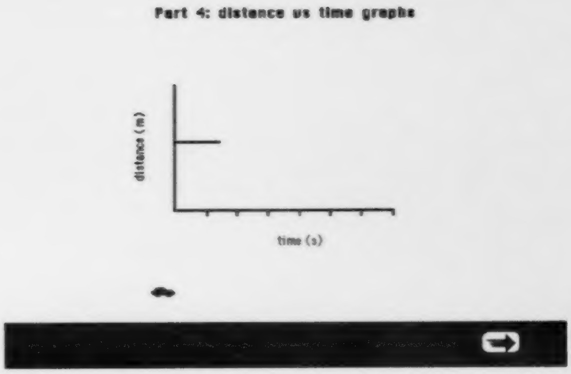

Part 4: distance vs time graphs

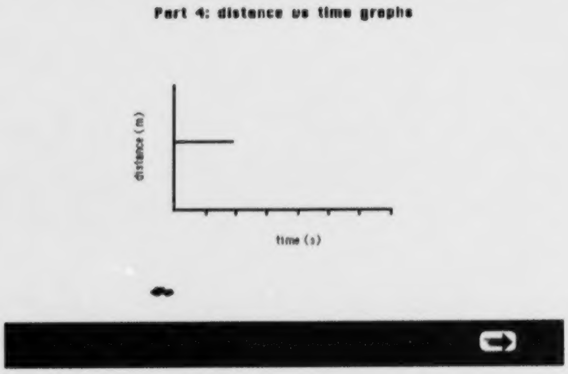
Press this button and observe the action.
Press this button
distance (m)
time (s)

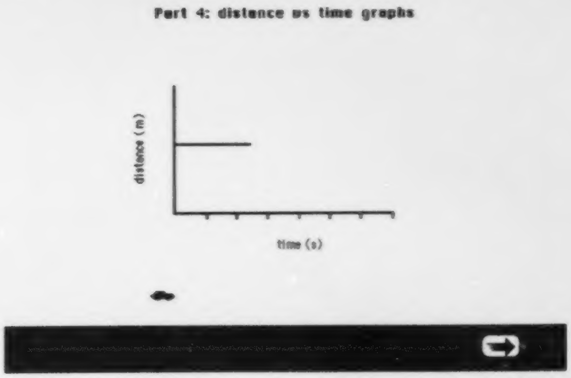

Part 4: distance vs time graphs
distance (m)
time (s)

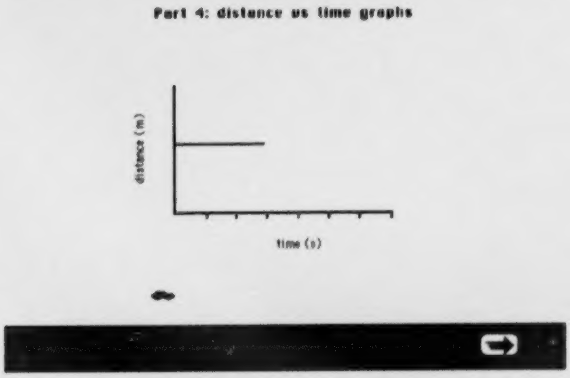

Part 4: distance vs time graphs
distance (m)
time (s)


Part 4: distance vs time graphs
distance (m)
time (s)

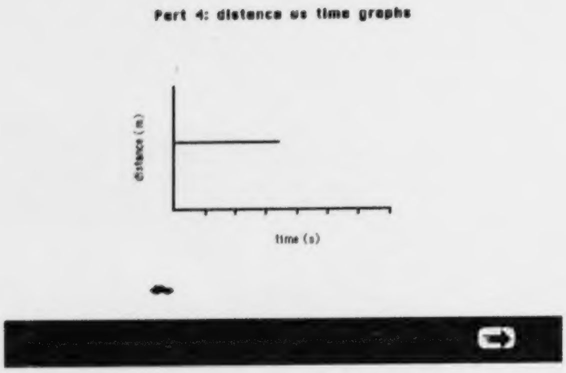

Part 4: distance vs time graphs
distance (m)
time (s)

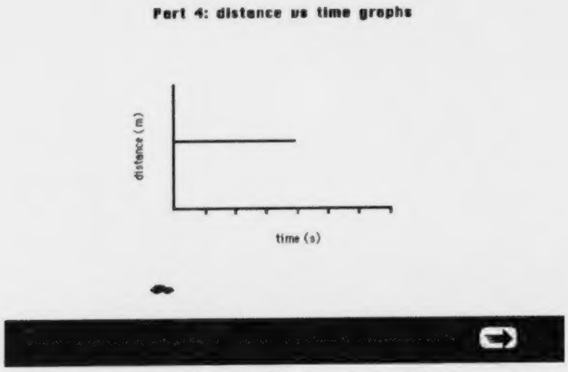

Part 4: distance vs time graphs
distance (m)
time (s)

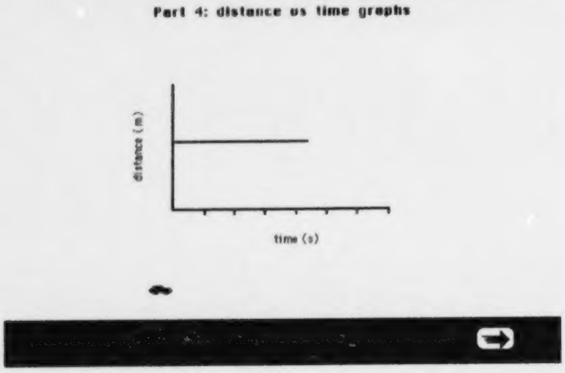

Part 4: distance vs time graphs
distance (m)
time (s)

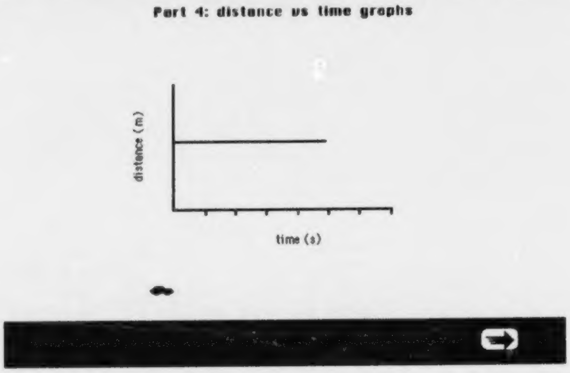

Part 4: distance vs time graphs
distance (m)
time (s)

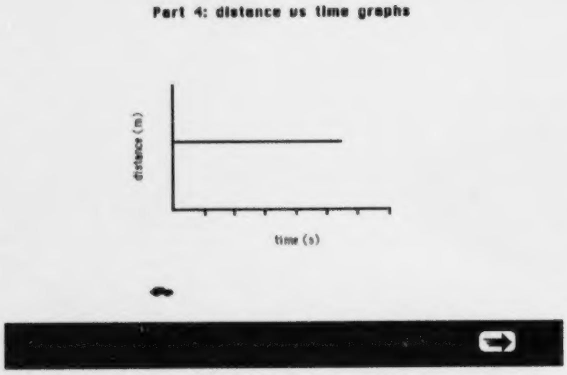
Motion

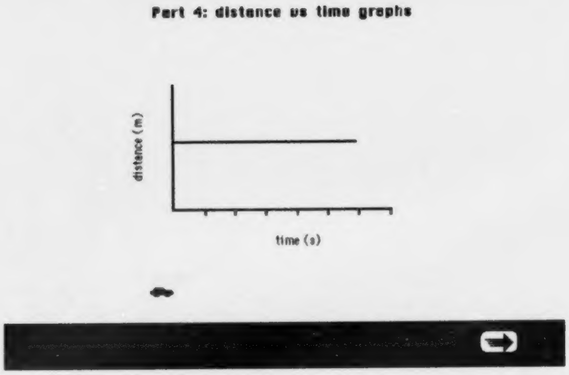

Part 4: distance vs time graphs
distance (m)
time (s)

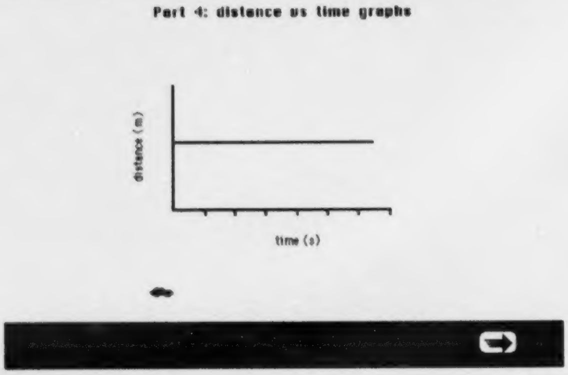

Part 4: distance vs time graphs
distance (m)
time (s)

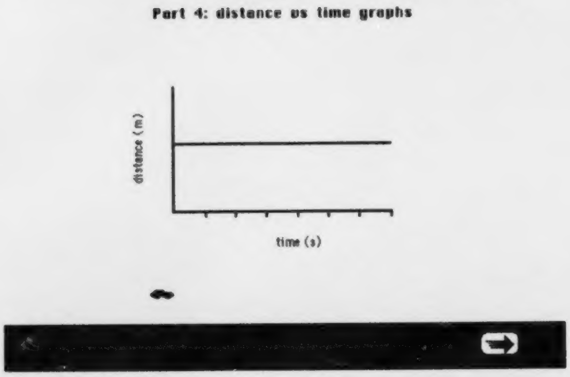

Part 4: distance vs time graphs
distance (m)
time (s)


Part 4: distance vs time graphs
distance (m)
time (s)

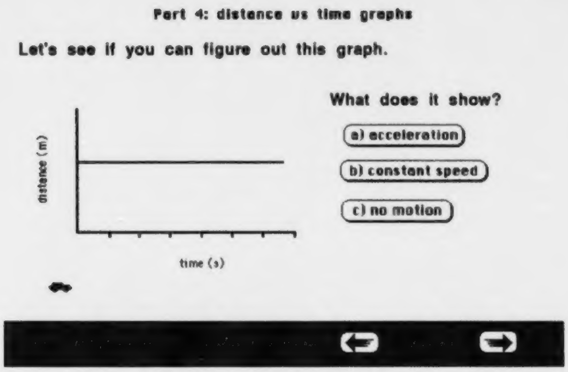

Part 4: distance vs time graphs
distance (m)
time (s)


Part 4: distance vs time graphs
distance (m)
time (s)


Part 4: distance vs time graphs
distance (m)
time (s)


Part 4: distance vs time graphs
distance (m)
time (s)

Motion

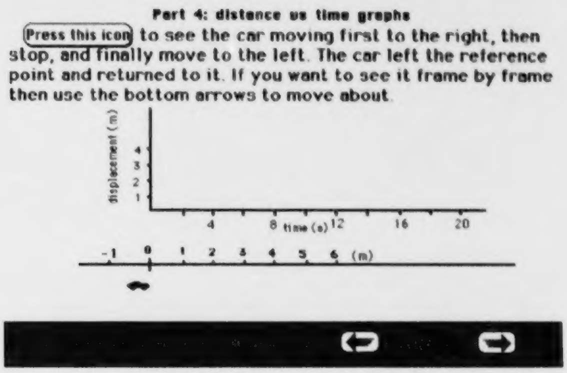


Part 4: distance vs time graphs

Let's see if you can figure out this graph.

What does it show?

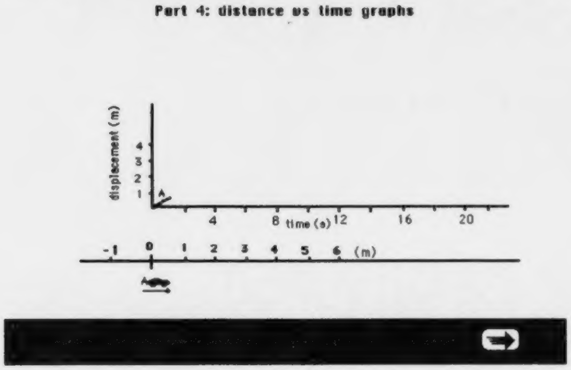
a) acceleration
b) constant speed
c) no motion
distance (m)
time (s)



Part 4: distance vs time graphs

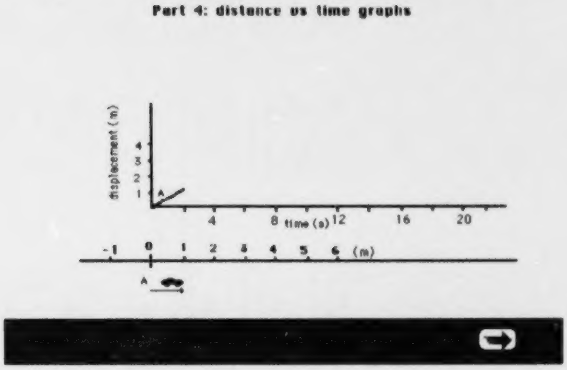
Press this icon to see the car moving first to the right, then stop, and finally move to the left. The car left the reference point and returned to it. If you want to see it frame by frame then use the bottom arrows to move about.

displacement (m)
1
2
3
4
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)



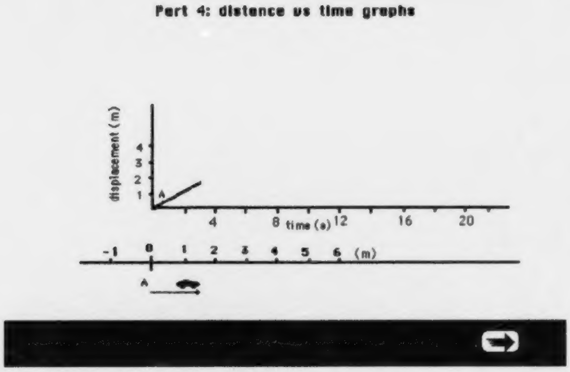
Part 4: distance vs time graphs

displacement (m)
1
2
3
4
A
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
A



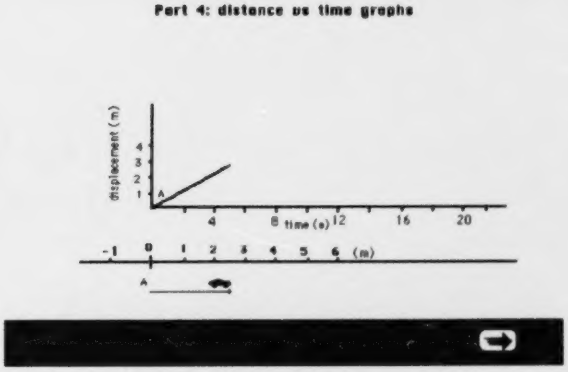
Part 4: distance vs time graphs

displacement (m)
1
2
3
4
A
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
A



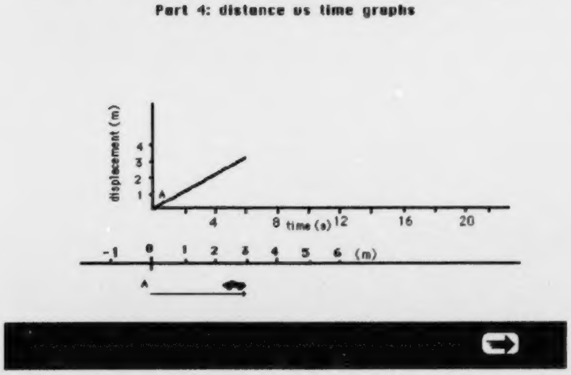
Part 4: distance vs time graphs

displacement (m)
1
2
3
4
A
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
A



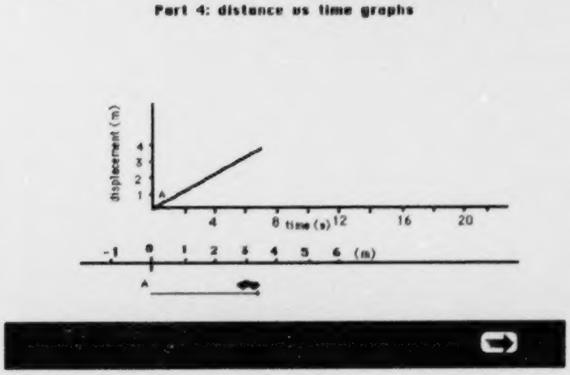
Part 4: distance vs time graphs

displacement (m)
1
2
3
4
A
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
A



Part 4: distance vs time graphs

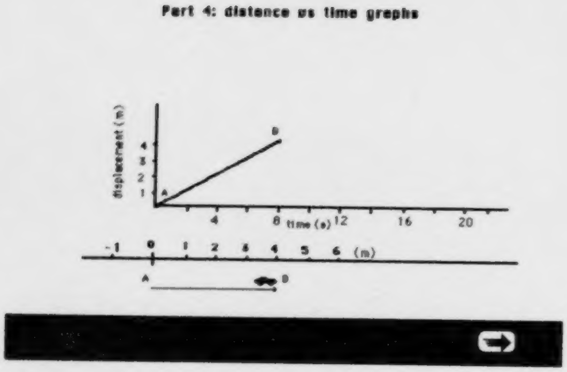
displacement (m)
1
2
3
4
A
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
A

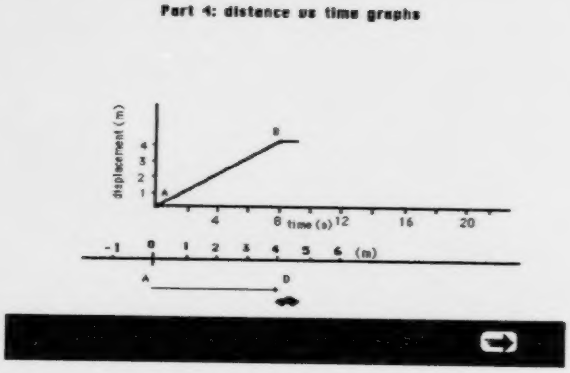


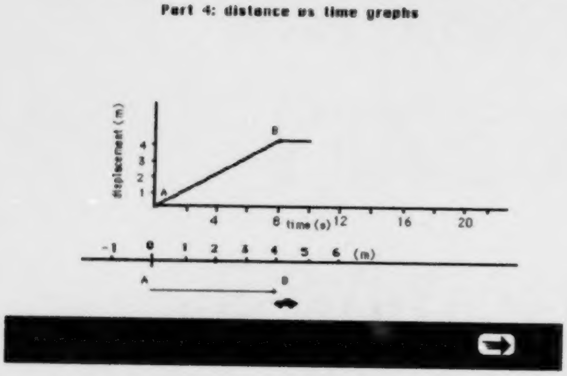
Part 4: distance vs time graphs

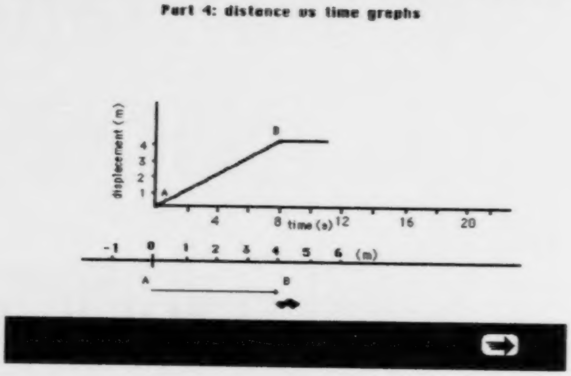
displacement (m)
1
2
3
4
A
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
A

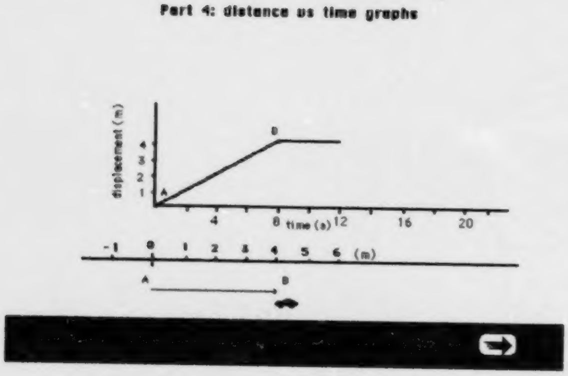
Motion

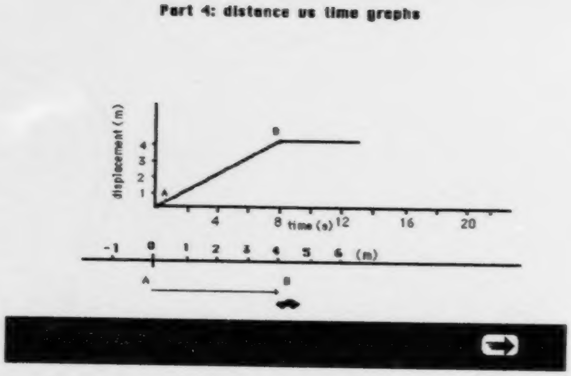

Part 4: distance vs time graphs
displacement (m)
1
2
3
4
A
B
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
A
B

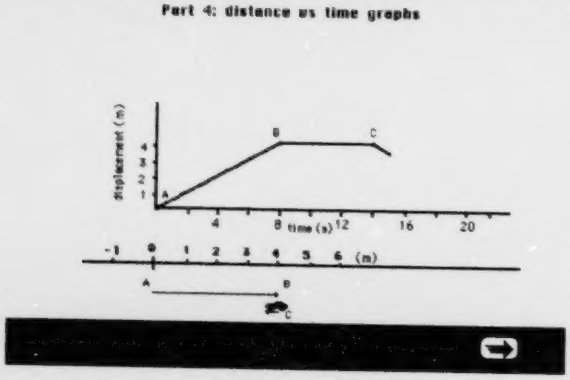

Part 4: distance vs time graphs
displacement (m)
1
2
3
4
A
B
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
A
B

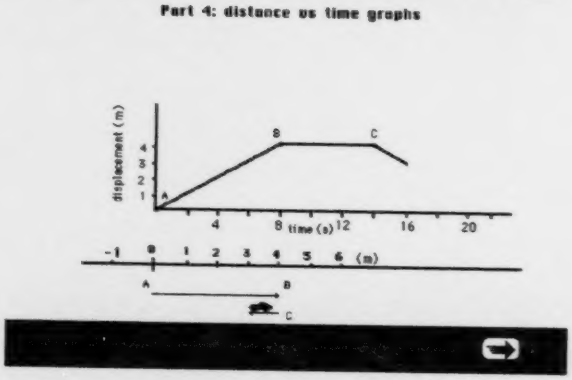

Part 4: distance vs time graphs
displacement (m)
1
2
3
4
A
B
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
A
B


Part 4: distance vs time graphs
displacement (m)
1
2
3
4
A
B
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
A
B

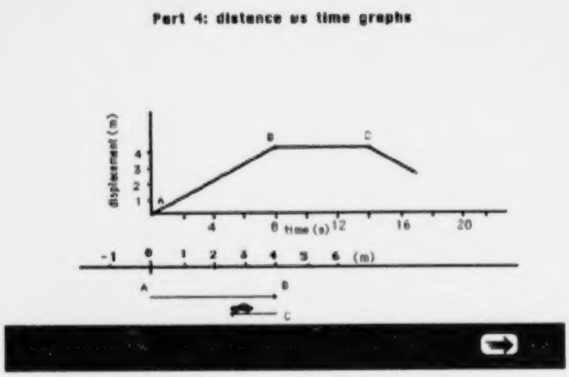

Part 4: distance vs time graphs
displacement (m)
1
2
3
4
A
B
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
A
B

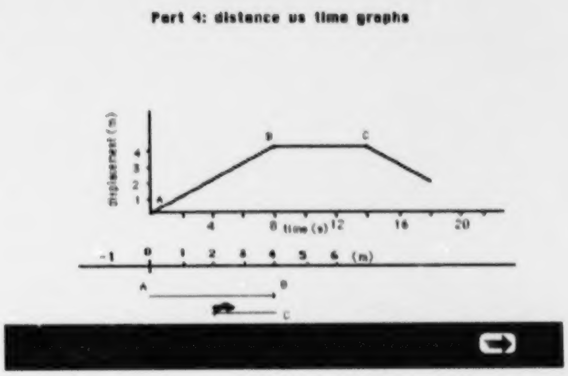

Part 4: distance vs time graphs
displacement (m)
1
2
3
4
A
B
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
A
B

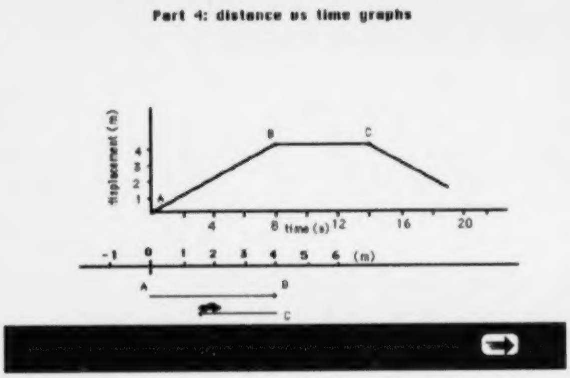

Part 4: distance vs time graphs
displacement (m)
1
2
3
4
A
B
C
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
A
B
C

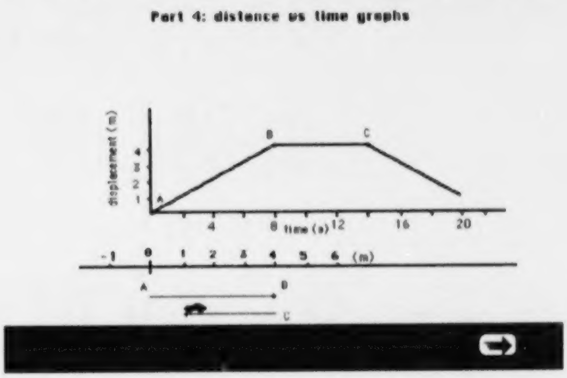

Part 4: distance vs time graphs
displacement (m)
1
2
3
4
A
B
C
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
A
B
C

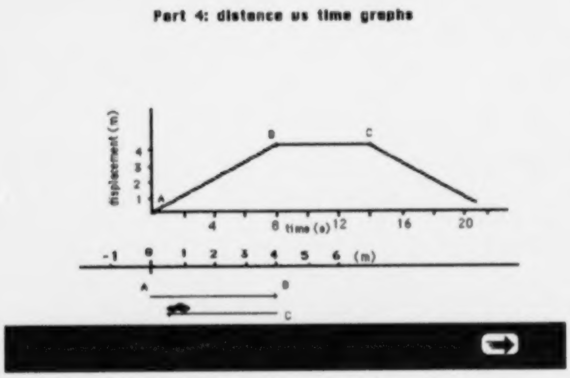
Motion

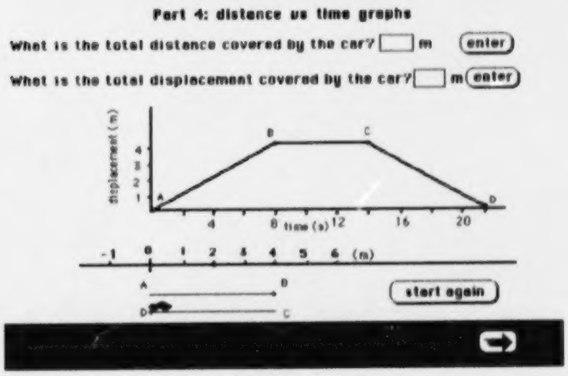

Part 4: distance vs time graphs
displacement (m)
1
2
3
4
A
B
C
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)


Part 4: distance vs time graphs
displacement (m)
1
2
3
4
A
B
C
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)


Part 4: distance vs time graphs
displacement (m)
1
2
3
4
A
B
C
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)

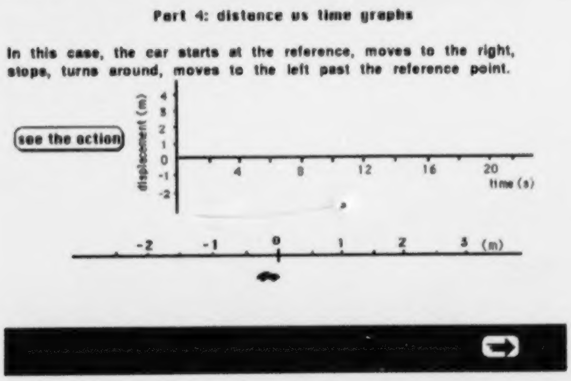

Part 4: distance vs time graphs
displacement (m)
1
2
3
4
A
B
C
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)


Part 4: distance vs time graphs
displacement (m)
1
2
3
4
A
B
C
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)

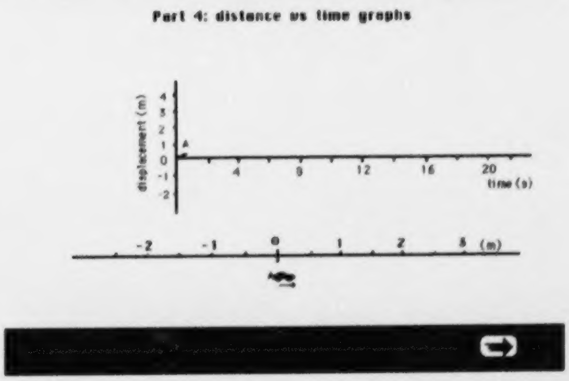

Part 4: distance vs time graphs

What is the total distance covered by the car? ☐ m (enter)

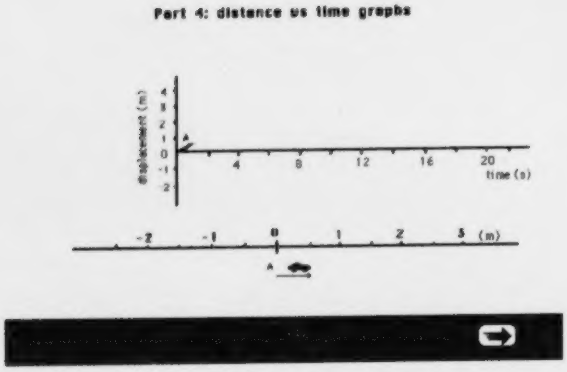
What is the total displacement covered by the car? ☐ m (enter)
displacement (m)
1
2
3
4
A
B
C
D
4
8
time (s)
12
16
20
-1
0
1
2
3
4
5
6
(m)
start again


Part 4: distance vs time graphs

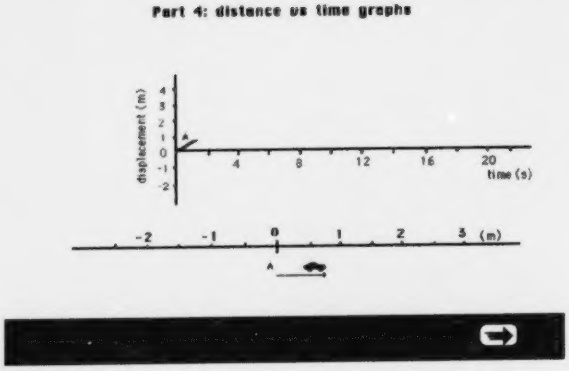
In this case, the car starts at the reference, moves to the right, stops, turns around, moves to the left past the reference point.
see the action
displacement (m)
4
3
2
1
0
-1
-2
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)


Part 4: distance vs time graphs
displacement (m)
4
3
2
1
0
-1
-2
A
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)

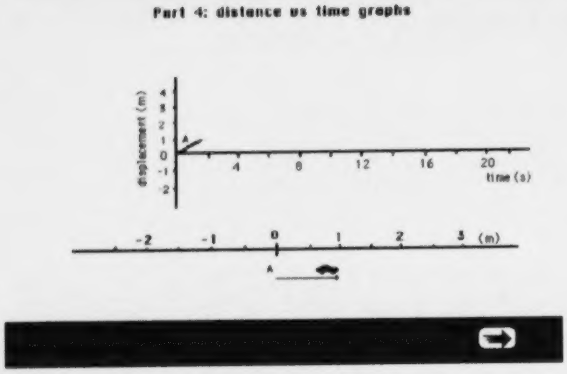
Motion


Part 4: distance vs time graphs

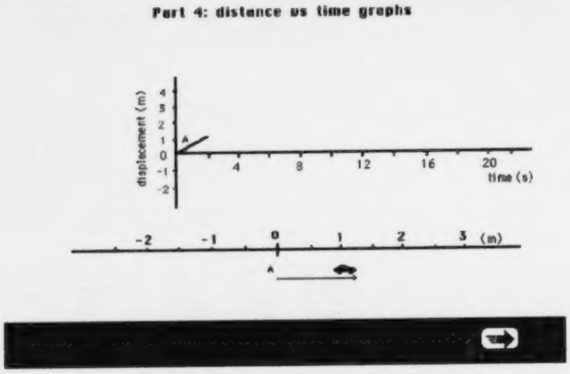
displacement (m)
4
3
2
1
0
-1
-2
4
8
12
16
20
time (s)
A
-2
-1
0
1
2
3
(m)
A


Part 4: distance vs time graphs

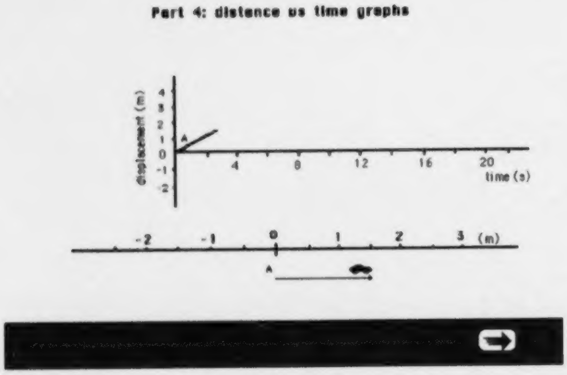
displacement (m)
4
3
2
1
0
-1
-2
4
8
12
16
20
time (s)
A
-2
-1
0
1
2
3
(m)
A


Part 4: distance vs time graphs

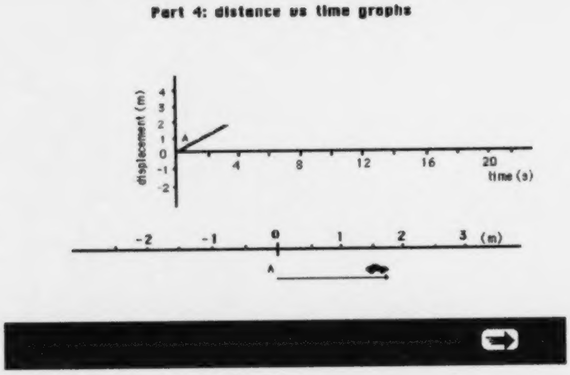
displacement (m)
4
3
2
1
0
-1
-2
4
8
12
16
20
time (s)
A
-2
-1
0
1
2
3
(m)
A


Part 4: distance vs time graphs

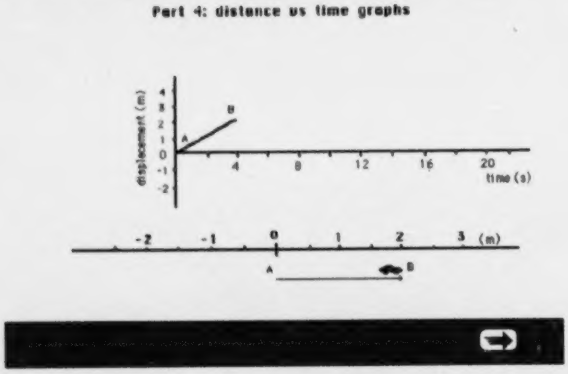
displacement (m)
4
3
2
1
0
-1
-2
4
8
12
16
20
time (s)
A
-2
-1
0
1
2
3
(m)
A


Part 4: distance vs time graphs

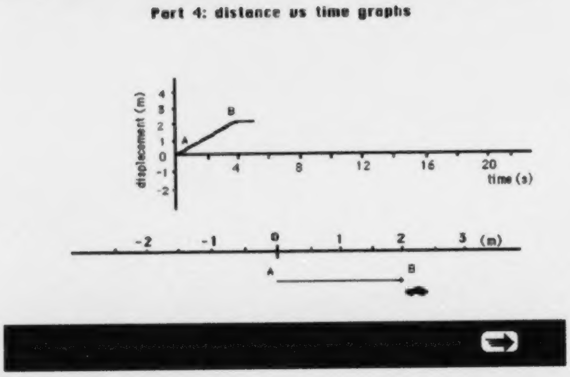
displacement (m)
4
3
2
1
0
-1
-2
4
8
12
16
20
time (s)
A
-2
-1
0
1
2
3
(m)
A


Part 4: distance vs time graphs

displacement (m)
4
3
2
1
0
-1
-2
4
8
12
16
20
time (s)
A
-2
-1
0
1
2
3
(m)
A

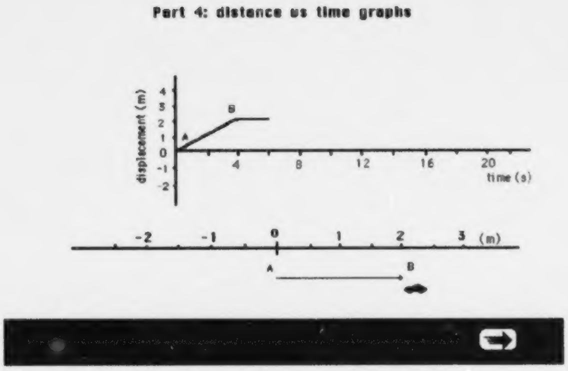

Part 4: distance vs time graphs

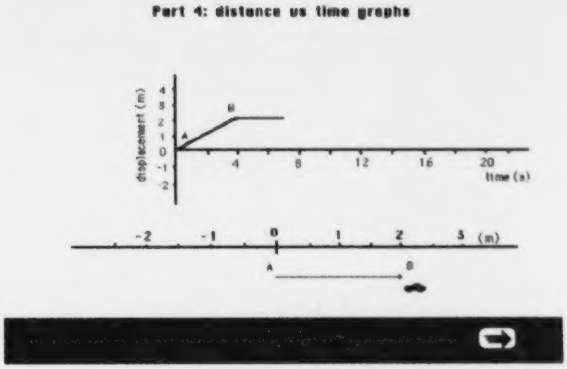
displacement (m)
4
3
2
1
0
-1
-2
4
8
12
16
20
time (s)
A
B
-2
-1
0
1
2
3
(m)
A
B

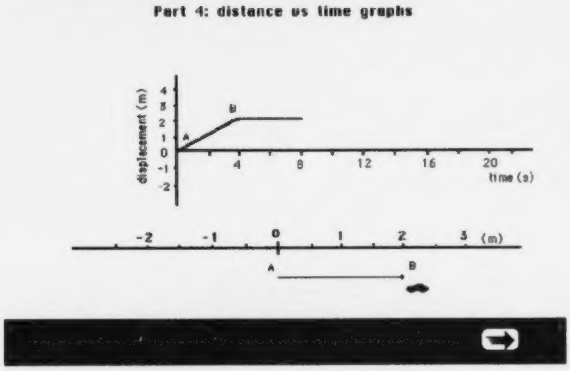

Part 4: distance vs time graphs

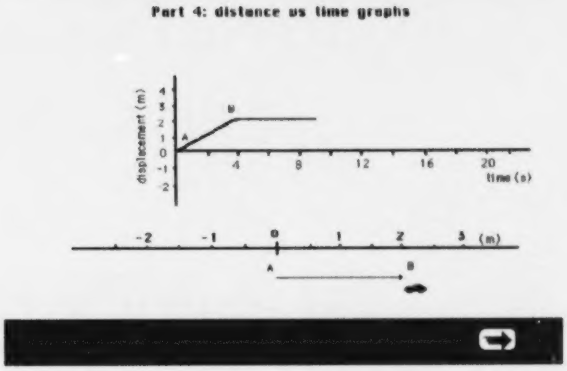
displacement (m)
4
3
2
1
0
-1
-2
4
8
12
16
20
time (s)
A
B
-2
-1
0
1
2
3
(m)
A
B

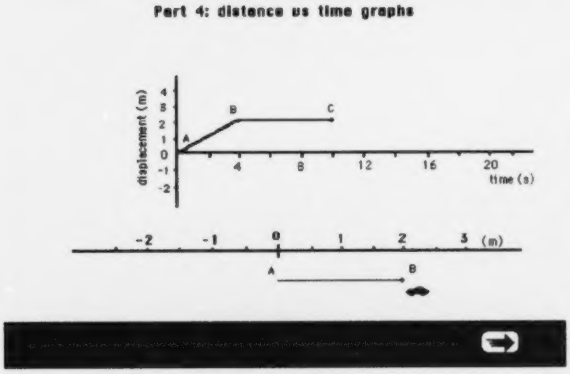
Motion

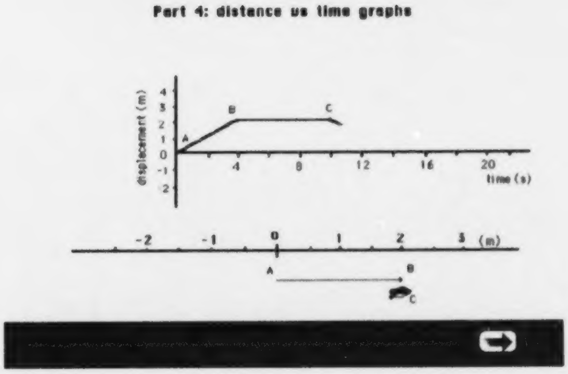

Part 4: distance vs time graphs
displacement (m)
4
3
2
1
0
-1
-2
A
B
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)
A
B

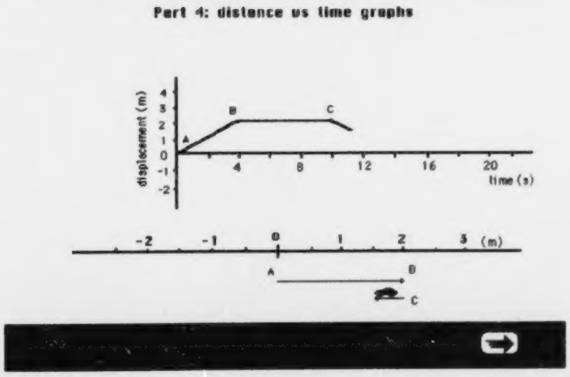

Part 4: distance vs time graphs
displacement (m)
4
3
2
1
0
-1
-2
A
B
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)
A
B

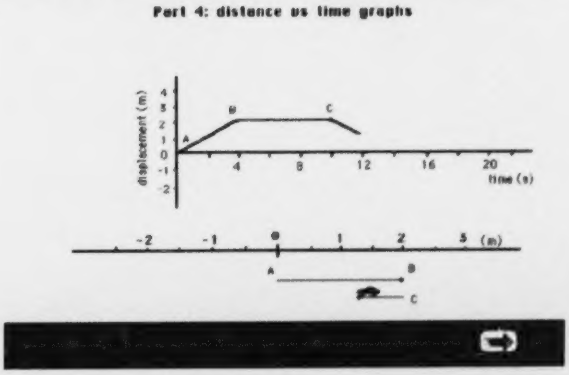

Part 4: distance vs time graphs
displacement (m)
4
3
2
1
0
-1
-2
A
B
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)
A
B


Part 4: distance vs time graphs
displacement (m)
4
3
2
1
0
-1
-2
A
B
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)
A
B

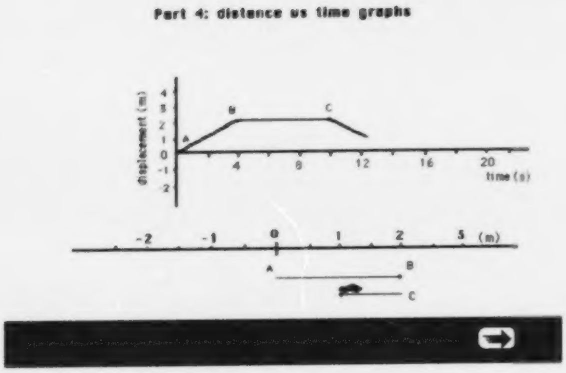

Part 4: distance vs time graphs
displacement (m)
4
3
2
1
0
-1
-2
A
B
C
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)
A
B

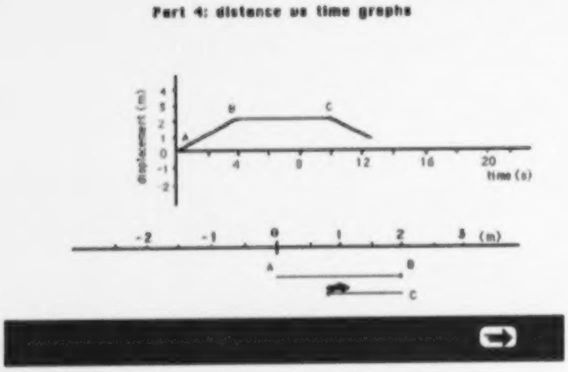

Part 4: distance vs time graphs
displacement (m)
4
3
2
1
0
-1
-2
A
B
C
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)
A
B
C

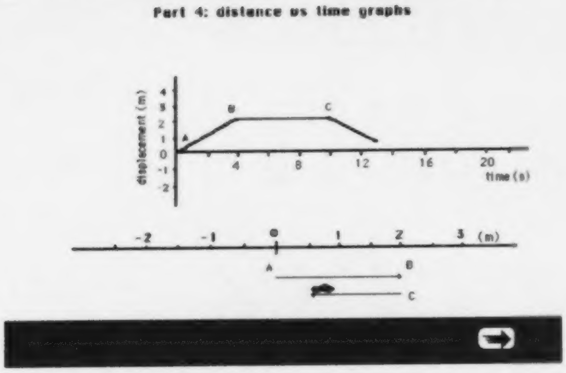

Part 4: distance vs time graphs
displacement (m)
4
3
2
1
0
-1
-2
A
B
C
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)
A
B
C

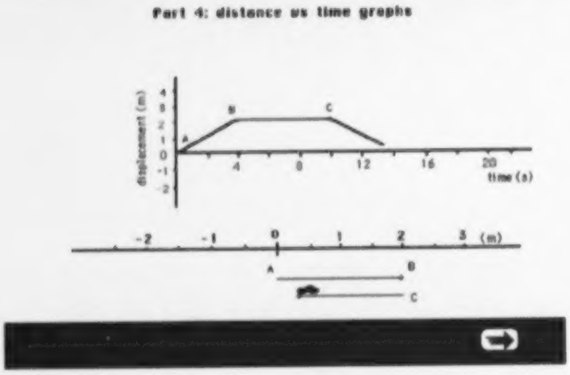

Part 4: distance vs time graphs
displacement (m)
4
3
2
1
0
-1
-2
A
B
C
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)
A
B
C

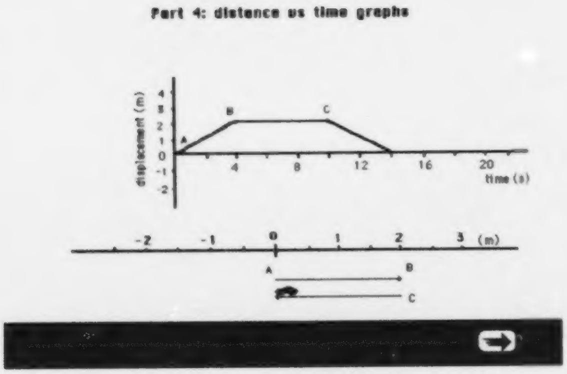
Motion

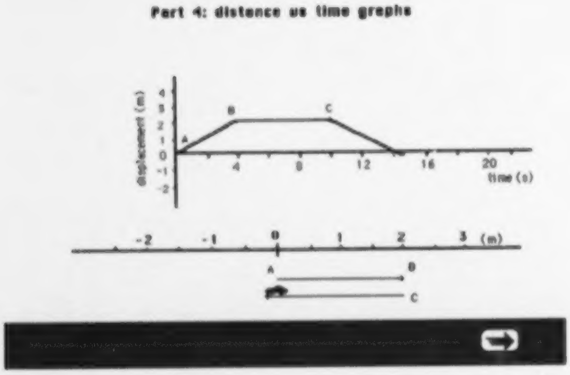

Part 4: distance vs time graphs
displacement (m)
time (s)
A
B
C
(m)

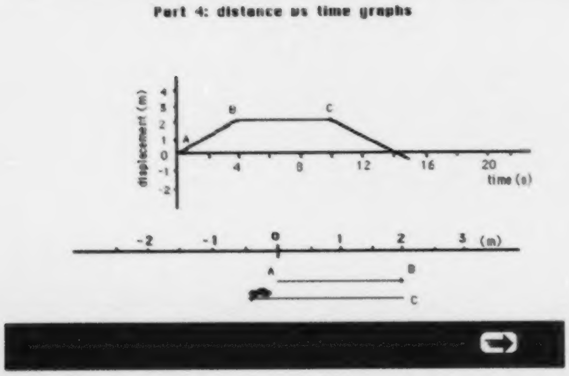

Part 4: distance vs time graphs
displacement (m)
time (s)
A
B
C
(m)

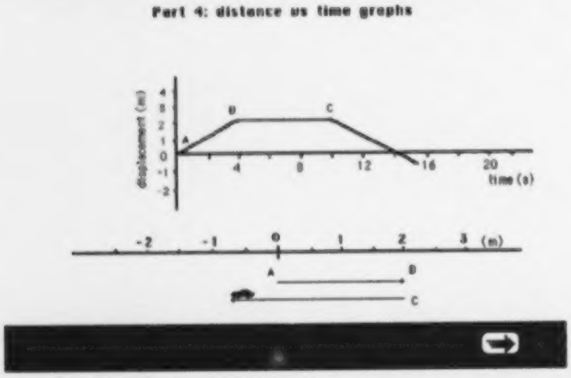

Part 4: distance vs time graphs
displacement (m)
time (s)
A
B
C
(m)


Part 4: distance vs time graphs
displacement (m)
time (s)
A
B
C
(m)

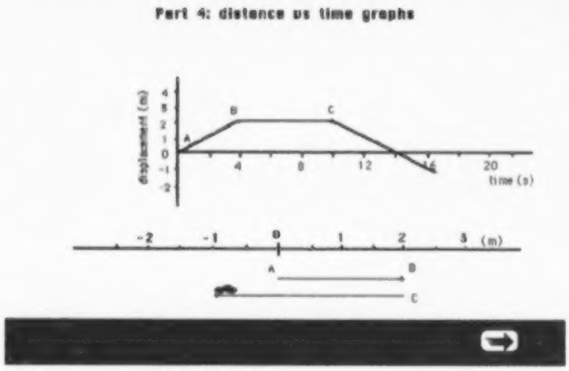

Part 4: distance vs time graphs
displacement (m)
time (s)
A
B
C
(m)

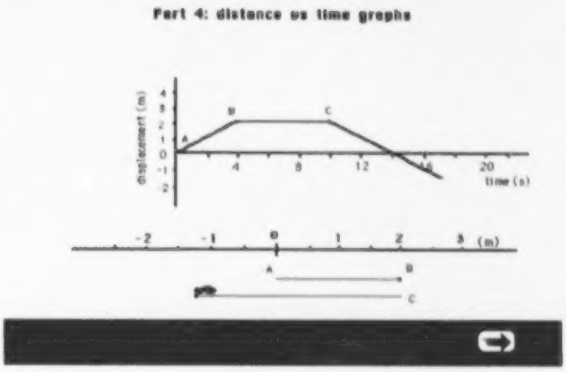

Part 4: distance vs time graphs
displacement (m)
time (s)
A
B
C
(m)

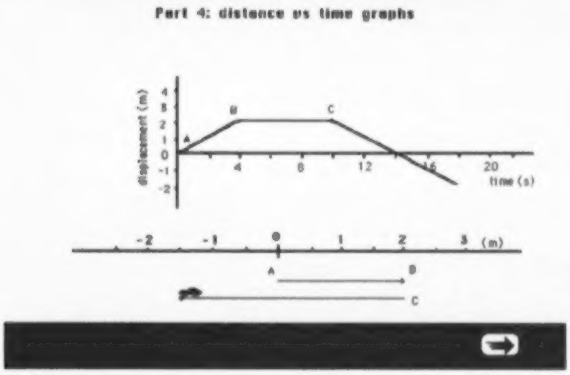

Part 4: distance vs time graphs
displacement (m)
time (s)
A
B
C
(m)

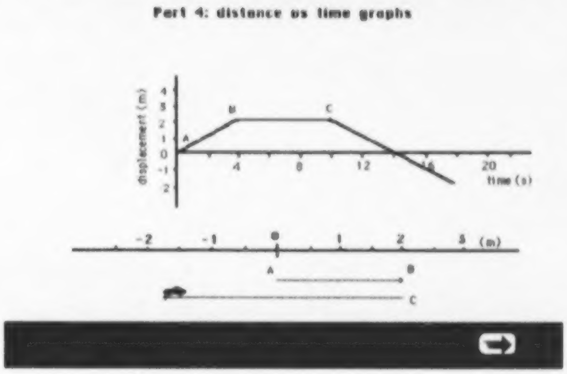

Part 4: distance vs time graphs
displacement (m)
time (s)
A
B
C
(m)

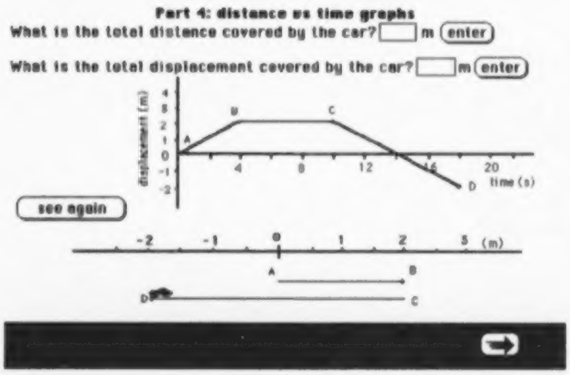
Motion


Part 4: distance vs time graphs
displacement (m)
4
3
2
1
0
-1
-2
A
B
C
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)
A
B
C


Part 4: distance vs time graphs
displacement (m)
4
3
2
1
0
-1
-2
A
B
C
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)
A
B
C

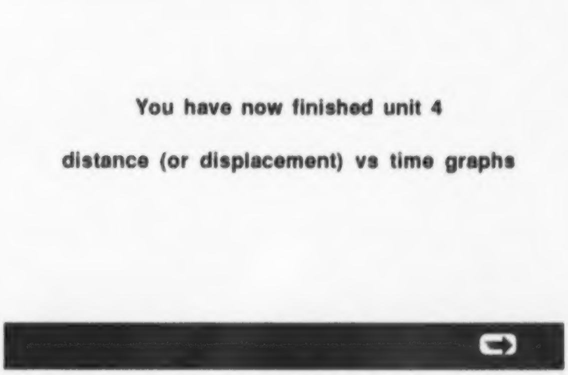

Part 4: distance vs time graphs
displacement (m)
4
3
2
1
0
-1
-2
A
B
C
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)
A
B
C


Part 4: distance vs time graphs
displacement (m)
4
3
2
1
0
-1
-2
A
B
C
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)
A
B
C

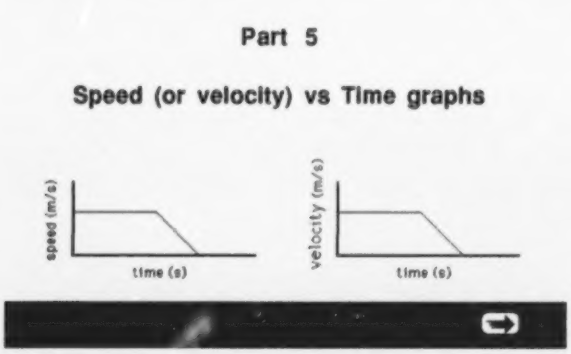

Part 4: distance vs time graphs

What is the total distance covered by the car? ☐ m

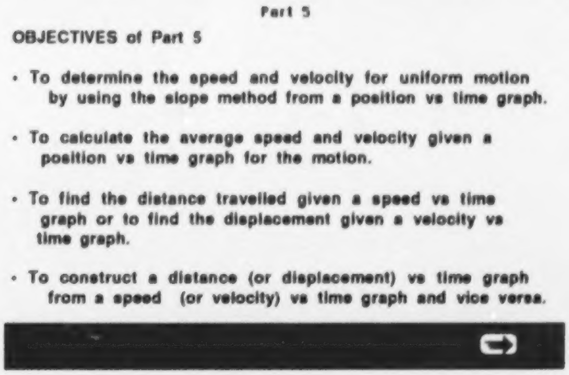
What is the total displacement covered by the car? ☐ m
enter
enter
see again
displacement (m)
4
3
2
1
0
-1
-2
A
B
C
D
4
8
12
16
20
time (s)
-2
-1
0
1
2
3
(m)
A
B
C
D


You have now finished unit 4

distance (or displacement) vs time graphs


Part 5

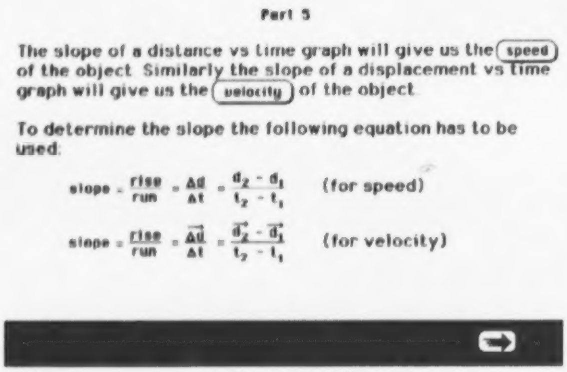
Speed (or velocity) vs Time graphs
speed (m/s)
time (s)
velocity (m/s)
time (s)


Part 5

OBJECTIVES of Part 5

- To determine the speed and velocity for uniform motion by using the slope method from a position vs time graph.
- To calculate the average speed and velocity given a position vs time graph for the motion.
- To find the distance travelled given a speed vs time graph or to find the displacement given a velocity vs time graph.
- To construct a distance (or displacement) vs time graph from a speed (or velocity) vs time graph and vice versa.

Motion



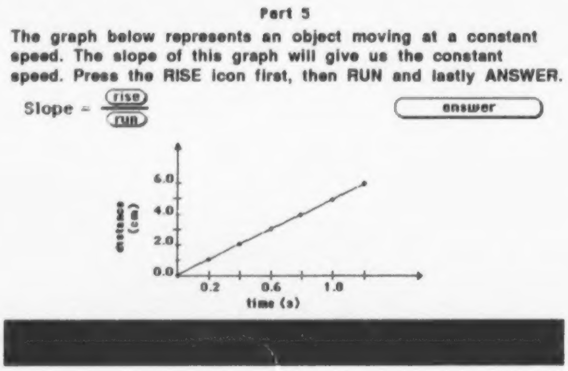
Part 5

The slope of a distance vs time graph will give us the speed of the object. Similarly the slope of a displacement vs time graph will give us the velocity of the object.

To determine the slope the following equation has to be used:

$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{\Delta d}{\Delta t} = \frac{d_2 - d_1}{t_2 - t_1} \quad \text{(for speed)}$$

$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{\overrightarrow{\Delta d}}{\Delta t} = \frac{\vec{d}_2 - \vec{d}_1}{t_2 - t_1} \quad \text{(for velocity)}$$

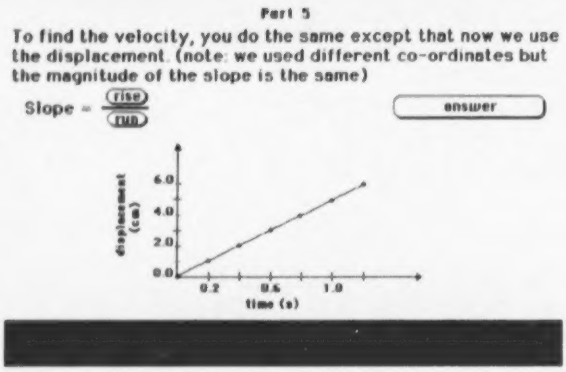


Part 5

The graph below represents an object moving at a constant speed. The slope of this graph will give us the constant speed. Press the RISE icon first, then RUN and lastly ANSWER.

$\text{Slope} = \frac{\text{rise}}{\text{run}}$ answer

6.0
4.0
2.0
0.0
distance (cm)
0.2
0.6
1.0
time (s)

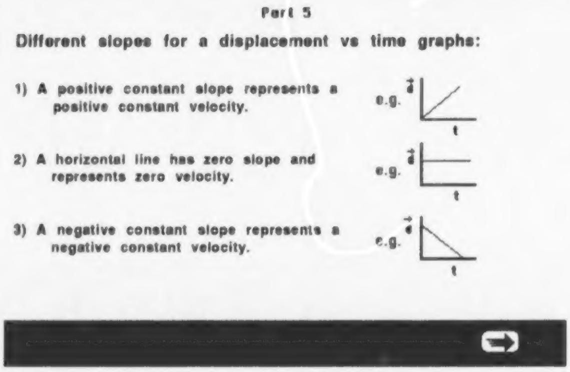


Part 5

To find the velocity, you do the same except that now we use the displacement. (note: we used different co-ordinates but the magnitude of the slope is the same)

$\text{Slope} = \frac{\text{rise}}{\text{run}}$ answer

6.0
4.0
2.0
0.0
displacement (cm)
0.2
0.6
1.0
time (s)

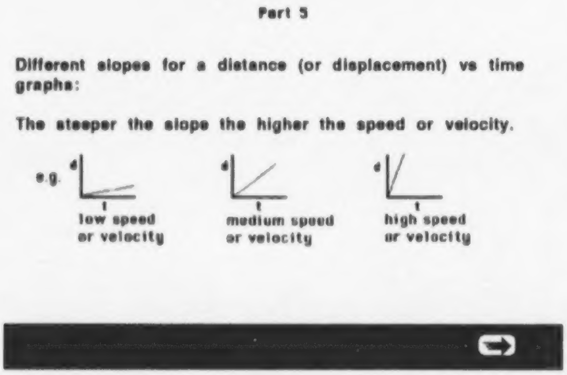


Part 5

Different slopes for a displacement vs time graphs:

1) A positive constant slope represents a positive constant velocity. e.g.
2) A horizontal line has zero slope and represents zero velocity. e.g.
3) A negative constant slope represents a negative constant velocity. e.g.

$\vec{d}$
t
$\vec{d}$
t
$\vec{d}$
t



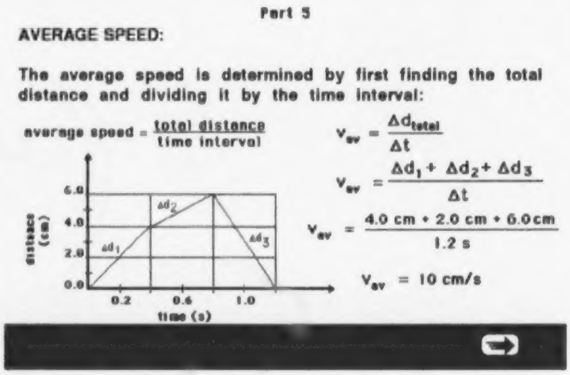
Part 5

Different slopes for a distance (or displacement) vs time graphs:

The steeper the slope the higher the speed or velocity.

e.g.

d
t
low speed or velocity
d
t
medium speed or velocity
d
t
high speed or velocity



Part 5

AVERAGE SPEED:

The average speed is determined by first finding the total distance and dividing it by the time interval:

$$\text{average speed} = \frac{\text{total distance}}{\text{time interval}}$$

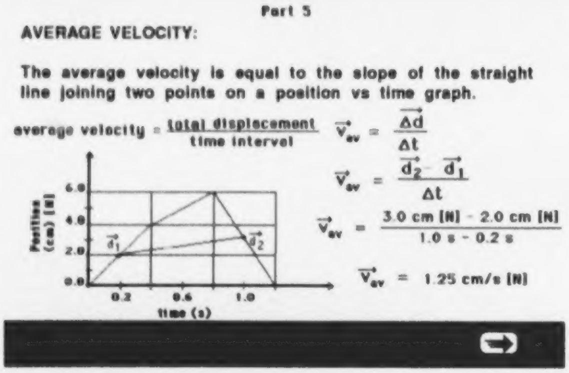
$$V_{av} = \frac{\Delta d_{total}}{\Delta t}$$

$$V_{av} = \frac{\Delta d_1 + \Delta d_2 + \Delta d_3}{\Delta t}$$

$$V_{av} = \frac{4.0\text{ cm} + 2.0\text{ cm} + 6.0\text{ cm}}{1.2\text{ s}}$$

$$V_{av} = 10\text{ cm/s}$$

6.0
4.0
2.0
0.0
distance (cm)
Δd_1
Δd_2
Δd_3
0.2
0.6
1.0
time (s)



Part 5

AVERAGE VELOCITY:

The average velocity is equal to the slope of the straight line joining two points on a position vs time graph.

$$\text{average velocity} = \frac{\text{total displacement}}{\text{time interval}}$$

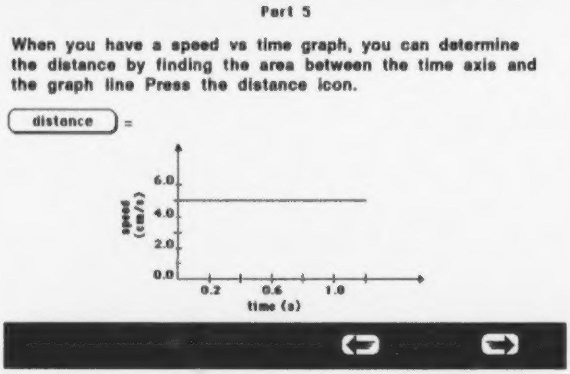
$$\vec{V}_{av} = \frac{\overrightarrow{\Delta d}}{\Delta t}$$

$$\vec{V}_{av} = \frac{\vec{d}_2 - \vec{d}_1}{\Delta t}$$

$$\vec{V}_{av} = \frac{3.0\text{ cm [N]} - 2.0\text{ cm [N]}}{1.0\text{ s} - 0.2\text{ s}}$$

$$\vec{V}_{av} = 1.25\text{ cm/s [N]}$$

6.0
4.0
2.0
0.0
Position (cm) [N]
$\vec{d}_1$
$\vec{d}_2$
0.2
0.6
1.0
time (s)



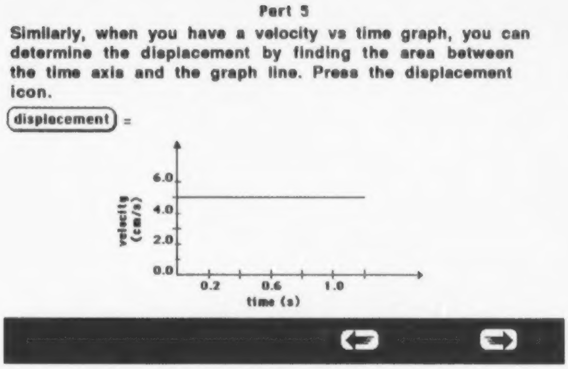
Part 5

When you have a speed vs time graph, you can determine the distance by finding the area between the time axis and the graph line Press the distance icon.

distance =

6.0
4.0
2.0
0.0
speed (cm/s)
0.2
0.6
1.0
time (s)

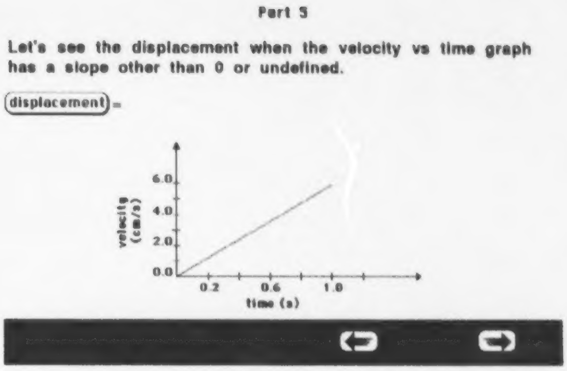
Motion



Part 5

Similarly, when you have a velocity vs time graph, you can determine the displacement by finding the area between the time axis and the graph line. Press the displacement icon.

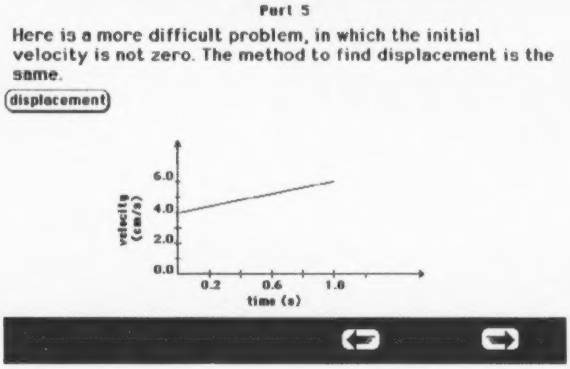
displacement =
velocity (cm/s)
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)



Part 5

Let's see the displacement when the velocity vs time graph has a slope other than 0 or undefined.

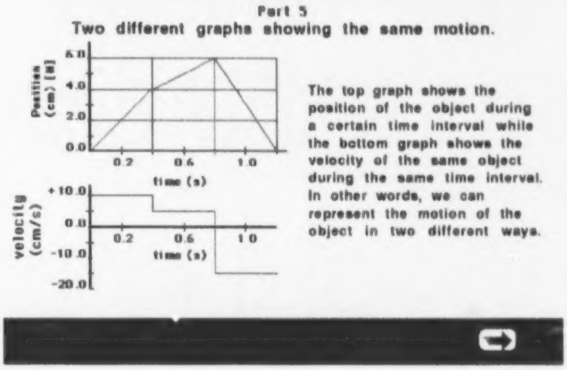
displacement =
velocity (cm/s)
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)



Part 5

Here is a more difficult problem, in which the initial velocity is not zero. The method to find displacement is the same.

displacement
velocity (cm/s)
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)

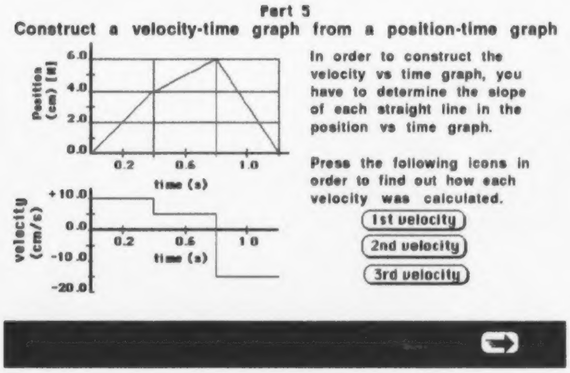


Part 5

Two different graphs showing the same motion.

The top graph shows the position of the object during a certain time interval while the bottom graph shows the velocity of the same object during the same time interval. In other words, we can represent the motion of the object in two different ways.

Position (cm) [m]
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)
velocity (cm/s)
+10.0
0.0
-10.0
-20.0
0.2
0.6
1.0
time (s)



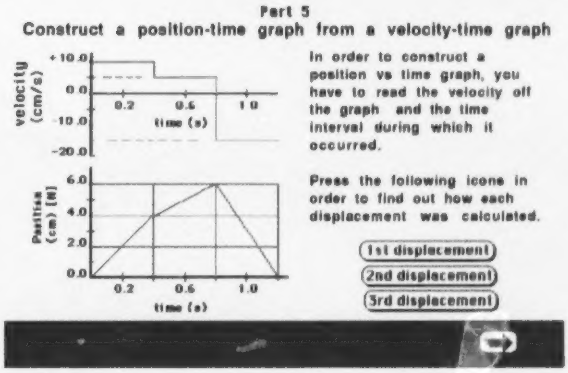
Part 5

Construct a velocity-time graph from a position-time graph

In order to construct the velocity vs time graph, you have to determine the slope of each straight line in the position vs time graph.

Press the following icons in order to find out how each velocity was calculated.

1st velocity
2nd velocity
3rd velocity
Position (cm) [m]
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)
velocity (cm/s)
+10.0
0.0
-10.0
-20.0
0.2
0.6
1.0
time (s)



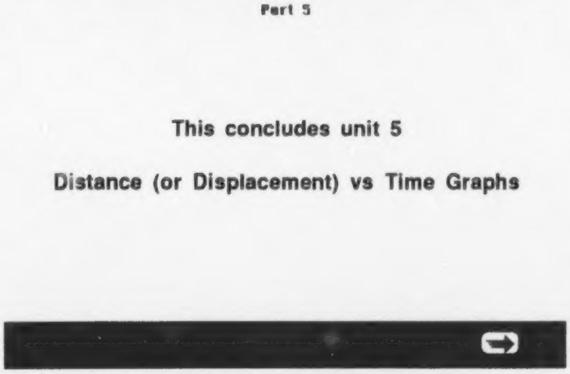
Part 5

Construct a position-time graph from a velocity-time graph

In order to construct a position vs time graph, you have to read the velocity off the graph and the time interval during which it occurred.

Press the following icons in order to find out how each displacement was calculated.

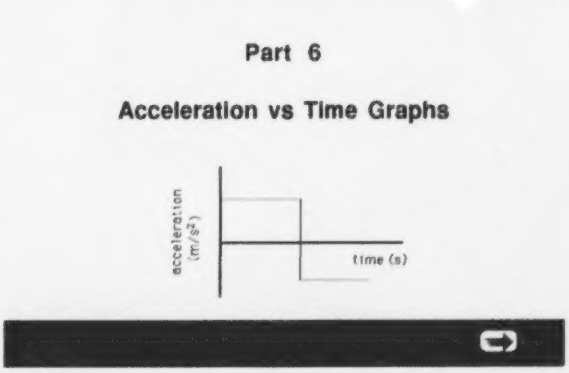
1st displacement
2nd displacement
3rd displacement
velocity (cm/s)
+10.0
0.0
-10.0
-20.0
0.2
0.6
1.0
time (s)
Position (cm) [m]
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)



Part 5

This concludes unit 5

Distance (or Displacement) vs Time Graphs

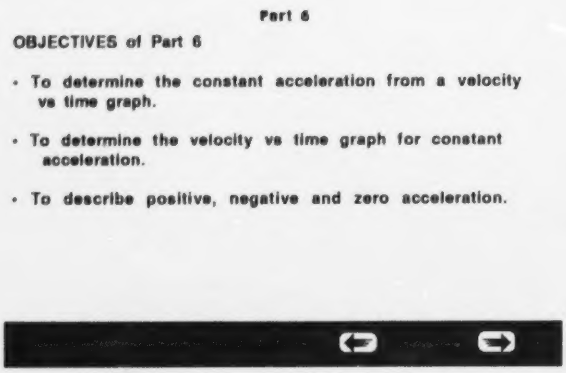


Part 6

Acceleration vs Time Graphs

acceleration (m/s²)
time (s)

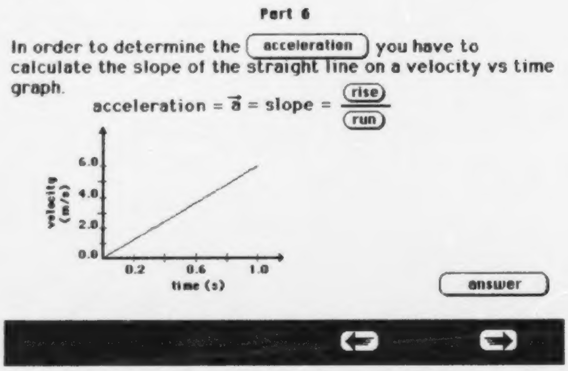
Motion



Part 6

OBJECTIVES of Part 6

- To determine the constant acceleration from a velocity vs time graph.
- To determine the velocity vs time graph for constant acceleration.
- To describe positive, negative and zero acceleration.

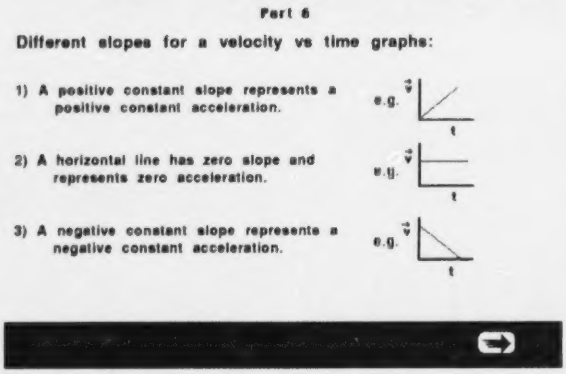


Part 6

In order to determine the acceleration you have to calculate the slope of the straight line on a velocity vs time graph.

$$\text{acceleration} = \vec{a} = \text{slope} = \frac{\text{rise}}{\text{run}}$$

velocity (m/s)
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)
answer



Part 6

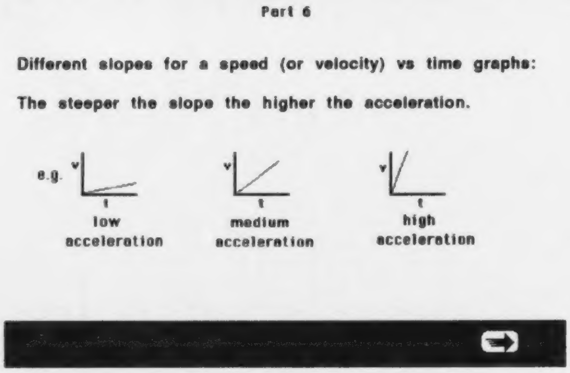
Different slopes for a velocity vs time graphs:

1) A positive constant slope represents a positive constant acceleration.

2) A horizontal line has zero slope and represents zero acceleration.

3) A negative constant slope represents a negative constant acceleration.

e.g. $\vec{v}$ t
e.g. $\vec{v}$ t
e.g. $\vec{v}$ t

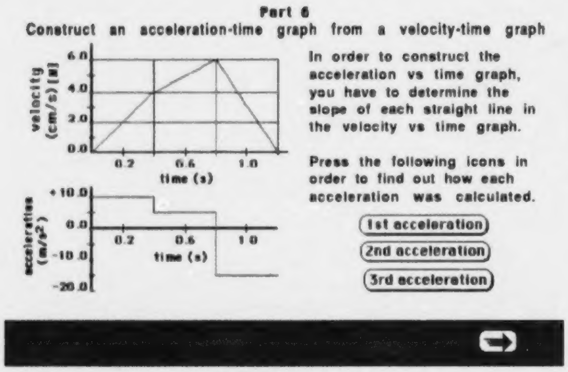


Part 6

Different slopes for a speed (or velocity) vs time graphs:

The steeper the slope the higher the acceleration.

e.g. v t
low acceleration
v t
medium acceleration
v t
high acceleration



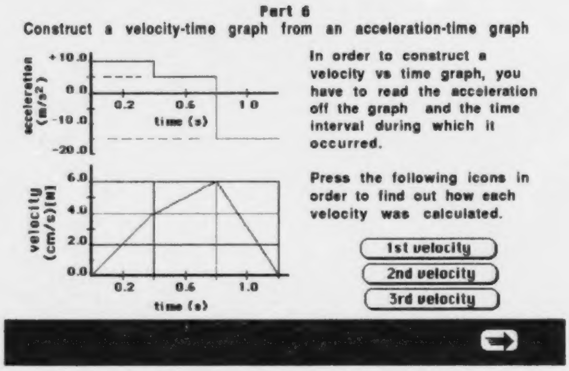
Part 6

Construct an acceleration-time graph from a velocity-time graph

In order to construct the acceleration vs time graph, you have to determine the slope of each straight line in the velocity vs time graph.

Press the following icons in order to find out how each acceleration was calculated.

velocity (cm/s) [E]
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)
acceleration (m/s²)
+10.0
0.0
-10.0
-20.0
0.2
0.6
1.0
time (s)
1st acceleration
2nd acceleration
3rd acceleration



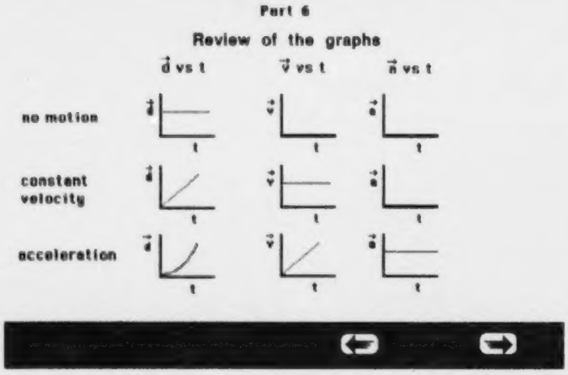
Part 6

Construct a velocity-time graph from an acceleration-time graph

In order to construct a velocity vs time graph, you have to read the acceleration off the graph and the time interval during which it occurred.

Press the following icons in order to find out how each velocity was calculated.

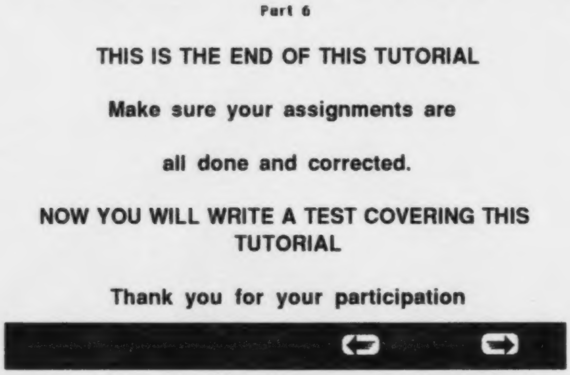
acceleration (m/s²)
+10.0
0.0
-10.0
-20.0
0.2
0.6
1.0
time (s)
velocity (cm/s)[E]
6.0
4.0
2.0
0.0
0.2
0.6
1.0
time (s)
1st velocity
2nd velocity
3rd velocity



Part 6

Review of the graphs

$\vec{d}$ vs t
$\vec{v}$ vs t
$\vec{a}$ vs t
no motion
constant velocity
acceleration
$\vec{d}$
$\vec{v}$
$\vec{a}$
t



Part 6

THIS IS THE END OF THIS TUTORIAL

Make sure your assignments are

all done and corrected.

NOW YOU WILL WRITE A TEST COVERING THIS TUTORIAL

Thank you for your participation